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KESTLIKU TÄNAVAVÕRGUSTIKU LOOMINE KARLOVA LINNAOSA NÄITEL, TARTUS

SUSTAINABLE STREET DESIGN: THE CASE OF KARLOVA DISTRICT, TARTU

Master's thesis
Curriculum in Landscape Architecture

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City streets are important arteries for urban communities and the city's economy. They form a large part of the public space of cities. The streets play an important role in promoting the economy and intra-urban mobility by offering residents and people the opportunity to move there on foot, by bicycle, by car or by public transport. The richness and vitality of cities requires well-thought-out street design. Street planning requires thorough preliminary work and cooperation among experts in their field to find the best possible solution. The aim of this master's thesis is to find out which solutions that support the environment can be used in street planning and whether and how to implement them in the Estonian climate. In order to find answers to the questions, a thorough literature search was conducted and a total of nine interviews with local government experts, road engineers and landscape architects were conducted. The results obtained were thoroughly analyzed. The obtained results were applied as example solutions in the conceptual design of the streets of Karlova district. The example solutions revealed which principles could be taken into account in the landscape architectural planning of streets and which techniques would be expedient to implement in Estonia, Tartu. The results of the research could be useful for people in the entire planning field, giving an overview of the main aspects of user-friendly and sustainable urban street planning.

Keywords: green structure, human-centered street space, sustainable materials, ecological stormwater systems.

CONTENTS

INTRODUCTION

This research has been prepared from the perspective of a landscape architecture student about the design of a sustainable street space. Incorporating sustainability into the streetscape is one of the most important aspects of sustainable urban planning (Rehan, 2012). As a result, the research aims to find long-term streetscape solutions in the urban environment.

The goal of this work is to inspire designers, urban planners, and practitioners to consider how public streetspace could function. Urban dwellers and others use city streets for movement or stationary activities, for recreation or for work, because of necessity or by choice.

The primary function of city streets is to ensure the mobility and accessibility of people in the city. By so far it seems that the road planning and construction has been focusing on building the infrastructure for vehicle movement leaving the people, animals, birds and greeneries secondary. Could it be reversed? Now that the streets are getting older and depreciated, how can we reconstruct them in the best possible way preserving the environment and preventing environmental problems? How can we make them more alive, more humane?

As mentioned previously this theme is important, because cities address the challenges of a warming world by designing streets that adapt to their surroundings. Many international organisations and agendas have intensified the emphasis on environmental sustainability, greenhouse gas emissions, and global warming. (Urban Street… 2016). On another hand, assuming that city streets are places for people, the question arises as to whether the streets are planned in the right user perspective. Is sustainability just the materials and construction techniques or is sustainability created by active and livable communities?

The primary research question is whether and how it is possible to renew existing street space by addressing current environmental issues and creating a viable urban environment. The goal of the project is to research long-term design measures and share and discuss their feasibility with urban planners and specialists, as well as to analyze the outcomes through design examples and additional feedback analysis. The author focuses on themes such as street green areas, people-oriented street planning, and building processes and materials in this work.

This following work is to find answers to the following questions:

- What are the main principles or methods of sustainable street design?
- How can these principles or methods be developed on the basis of sustainable streets?
- If and how can studied tools be used to design sustainable streets in Tartu, Estonia?

This work is divided into four sections. First of them presents a review of the theoretical literature by analyzing existing studies, projects and case study areas. The second chapter describes the hypothesis and methodology. The third presents research results and design experiments. The results include interview results with nine experts, three types of design experiments, and design feedback and its analysis. The research ends with a discussion.

Taking in mind that road construction depends on several actors - road designers, planners, political and institutional makers, builders, process managers, maintainers and so on landscape architects, road engineer and municipal planners in Tartu were chosen for more thorough discussion about sustainability and streets. The methodology was to develop research questions from a theoretical basis to discuss the possibilities on designing sustainable streets with the experts. Furthermore these results were combined into main principles of the design and three example designs were created to analyse the principles even more. For complete overview feedback on design was sent back to the expert for conclusions.

I would like to thank my supervisor, Jekaterina Balicka, for her consistent support and guidance throughout the research. In addition, I would like to thank the interviewees for their cooperation during data collection.

1 LITERATURE REVIEW

The following chapter outlines the definition, principles, and challenges of sustainable design. Secondly, it focuses on the analysis of tools that have been already developed. In addition it is searching for the current situation of Tartu street planning and case study district of Karlova.

1.1 Sustainable streetscape

What is a sustainable streetscape? Several studies have sought to answer this question. Sustainability in an urban context means that the city has strong social, economic, and environmental performances. Sustainable streets can be achieved by planning sustainable mobility and land use, and building with sustainable materials and technologies (Urban Street… 2013, Urban Street… 2016). The most common keywords describing sustainable streets are legit, safe, comfortable, inclusive, for everyone, resilient and long-lasting, multimodal, attractive without any visual clutter (El-Shimy et al., 2016; Urban Street… 2013; Rehan, 2012). Creating streets with ‘’green modes’’ is a movement towards livable urban communities where ecology and community together are embracing the environment and equity (El-Shimy et al., 2016; Rehan, 2012).

But what are the fundamental principles of a living street? These are, according to Urban Street... 2013, Urban Street... 2016, and El-Shimy et al., 2016, the following:

1. Street-space is a public space as well as corridors of movement. Because the street space is limited the activities need to be thought through so that different movements and activities could use the same space but at different times.

2. Street networks are for everyone to fulfill their basic needs- for traffic movement, people, people with disabilities, seniors, children, animals, birds, plants etc.

3. Streets are multidimensional spaces. Streets attract social and economic activities like walking, meeting in cafes, shopping, visiting museums etc.

4. Streets are multimodal. Sustainable streets have a range of mobility options. The streets should accommodate road users like walkers, cyclists, transit users, and

other vehicles. But where possible slow movement like walking and cycling should be primary.

5. Streets are ecosystems. Natural systems integrate with the street network at all scales. This kind of street network respects, protects and enhances the natural elements and ecological systems in urban environments. This result is a balanced, symbiotic community integrating stormwater treatment and incorporating stormwater flow and wildlife habitat zones into the street network.

However, designing a street is challenging and the main issues to work with are air quality, noise pollution, health and safety questions, water management, microclimate and energy consumption (El-Shimy et al., 2016; Farhadi, et al, 2019; Urban Street… 2013; Urban Street… 2016). Because most of the streets are designed for vehicles and the common urban place of residence is a flat means that there is a lack of outdoor space or backyards for most of the people. On one hand, there is a question on how to incorporate landscaping and trees into existing streetscapes to foster biodiversity and improve water management and increase access to the natural environment. On another hand, it brings out the question of how to prioritize pedestrians, cyclists, and soft transits on these roads (Jones et al., 2008) to offer urban dwellers more space to take as a calm and comfortable urban yard. With prioritizing slow mobility comes also safety questions. How to support different types of people as children, seniors, people with disabilities, etc.? How to improve traffic violence? What should the speed be to minimize conflicts and accidents in traffic? Is the visibility enough etc. (Urban Street… 2016) Planning the streetscape is a complex work and there are many more questions to solve planning and designing streets.

1.2 Instruments of sustainable streetscapes

1.2.1 Green infrastructure and biodiversity

In a city settlement, it is important that the hardscapes are in balance with the green elements. Many researches have found that providing green infrastructure will improve the general urban ecosystem, human well-being, and even economy (Ottosen et al, 2019; Rehan, 2012; El-Shimy et al., 2016; Farhadi et al., 2019; Weber et al., 2013; Säumel et al., 2015). Green infrastructure in urban street can be as trees, alleys, landscape strips, planters, shrubs, stormwater greeneries, flower beds (Rehan, 2012; El-Shimy et al., 2016; Farhadi et

al., 2019; Weber et al., 2013; Säumel et al., 2015), etc. and even green roofs (Rehan, 2012; Farhadi et al., 2019).

1.2.1.1 General maintenance and species selection

It is important to use urban tolerant local plant species while planning street vegetation and in some parts let the vegetation grow wildly to foster biodiversity (Rehan, 2012; Urban Street… 2016; Sämuel et al., 2015, Weber et al., 2019;). Many activities also damage plants, such as excessive trampling, breaking branches and flowers, and salting the streets.

The common street trees on the boulevard in Estonia are European Linden (*Tilia cordata),* Poplar (*Populus),* Larch (*Larix)* and Chestnut (*Castanea).* In addition native trees that are recommended in Estonian streets are European Alder (*Alnus glutinosa)*, Silver Birch (*Betula pendula*), European oak (*Quercus robur*), Swedish Whitebeam, (*Sorbus intermedia*), European White Elm (*Ulmus laevis*), European Mountain Ash, (*Sorbus aucuparia*), Norway Maple (*Acer platanoides*) (Tallinna tänava… 2011). Oaks and lindens grow dominantly in Tartu streets. In addition, many pyramid forms of common oak grow in Tartu.

On one hand, air pollution is not the best for plants, but at the same time deciduous trees help to balance polluted air. Namely, deciduous trees tolerate pollution better than conifers, because in autumn they lower the leaves with the accumulated pollution.

Usually, the bushes grow to a maximum height of 6 meters. Shrubs are generally easier to maintain, which is why shrubs are appreciable in street landscaping. Normally, shrubs are planted in a hole 60-90 cm wide. (Jürisoo, et al., 2014). Among the bushes common are: *Crataegus monogyna, Swida sanguinea, Viburnum opulus, Syringa L., Euonymus europaeus, Thuja occidentalis and Buxus sempervirens, from what Lonicera xylosteum, Cotoneaster L., Berberis vulgaris, and Ribes alpinum* are native (Kont et., al, 2003).

To support spatial planning, designers should consider the type and functionality of the street when designing streets. What is the street's purpose, what driving directions are important, what is the traffic speed, and what modes of transportation are available - all this is important to consider. Furthermore, what above-ground and underground utilities are present on the streets, as well as what maintenance standards are appropriate for the street (street cleaning machines, mowing, snow removal, etc.). (Jürisoo, et al., 2014)

Nurseries specialize in training young trees for use as street trees. Such trees are shaped and branching in such a way that the crown would be higher in the future and will not obstruct traffic or visibility. (Jürisoo, et al., 2014)

It is necessary to provide at least 15-20 cm of cultivated growing area in order to produce a good lawn. For meadow populations, 10-15 cm of soil is adequate. Lawns should be lower than pavement surfaces to ensure fair and environmentally sustainable stormwater management. Lawn care is one of the most expensive sources in urban parks and greeneries. Is such attention, however, really required? Tartu has experimented with allowing herbaceous vegetation to flourish in park and street areas. This kind of method requires only mowing herbaceous species a few times per year, which is beneficial to all living organisms and insects in the city. (Jürisoo, et al., 2014)

If it is not possible to establish green areas, the plants can also be planted in different containers, planting boxes. This method is very common in streets. Additional watering may be required for planting boxes. (Jürisoo, et al., 2014)

1.2.1.2 Microclimate and environmental impacts

Overall urban vegetation has mainly beneficial impacts on the environment (Ottosen et al., 2019; Sashua-Bar et al, 2010a!), but it could also have social and economic benefits (Urban Street… 2013).

Green areas benefits urban microclimate by:

- helping to reduce urban heat islands (Urban Street… 2016; Rehan, 2012);
- helping to regulate the temperature by shading and evapotranspiration (Säumel et al., 2015; Farhadi et al., 2019; Rehan, 2012);
- helping to reduce global warming risk (Farhadi et al., 2019).

Green areas reduce urban noise pollution (Rehan, 2012; Ottosen et al., 2019; Sashua-Bar et al, 2010a!) by 3-5 decibels (Urban Street… 2016). It is thanks to trees and their foliage. Trees with bigger leaves have a bigger effect (Säumel et al., 2015).

Green areas reduce air pollution (Urban Street… 2013; Urban Street… 2016; Weber et al., 2013) by:

- regulating carbon sequestration (Ottosen et al, 2019; Sashua-Bar et al, 2010a!);
- working like air filtration. Vegetation barriers can also work as shields reducing pollution and wind speed (Säumel et al., 2015).

Green areas benefits health and well-being by:

- helping to decrease stress and aggressive behaviour (Urban Street… 2016; Rehan, 2012);
- helping to promote positively physical activity (Säumel et al., 2015);
- increasing the perceived quality of life and aesthetic judgements (Säumel et al., 2015; Weber et al., 2013);
- positively influencing social contact and allowing people to maintain a connection with the natural elements (Weber et al., 2013).

However they can also cause health problems by allergenic proteins in the pollen (Säumel et al., 2015)

Green areas benefit the economy on one hand enhancing the movement (Urban Street… 2016). On another hand they are increasing property values by being more wanted by society (Säumel et al., 2015).

1.2.1.3 Biodiversity

The previous two tools are related to providing habitats. The existence of green infrastructure, corridors (Church, 2014), and urban wildlife (Beckmann, 2009) will increase biodiversity and enriches the ecosystem (Säumel et al., 2015; Ottosen et al, 2019). Following points are the values that wildlife and habitats can provide.

- Vegetated road corridors can function as parts of uban biotope networks by linking urban habitats (Säumel et al., 2015). It enhances wildlife habitat by providing insects, birds, amphibians, frogs, bats, squirrels, hedgehogs, foxes, rabbits space to exist.
- Bird songs along the road can decrease the sound of the traffic noise (Säumel et al., 2015).

- Grassland patches on roundabouts or other road enclosures support abundant insect populations (Säumel et al., 2015).

- It can increase biodiversity (Säumel et al., 2015)

Squirrels, hedgehogs, frogs, etc. live on streets and other urban green areas. Squirrels have a variety of foods in the city: conifer seeds, acorns, nuts, berries and other seeds. Hedgehogs and frogs eat green insects and other invertebrates. Walking through the streets you can see a lot of sparrows, pigeons, woodpeckers and crows. They live on walls, roofs and eaves, attics, park trees and bushes. The abundance of insects in the settlements, the contents of the bins and the people's habit of feeding the birds make it easier to get food. Seabirds such as the gull and silver gull have also become city birds. The city is also home to useful birds. For example, golden plovers, woodpeckers, nightshade and flaxseed. In addition to destroying pests, it's nice to hear their song. In winter, you can meet lichens in the city, eating seeds from trees and shrubs in flocks. Many people put nesting boxes and canteens on useful birds.

It is quite easy for birds and animals to live in settlements and cities, but it is also quite dangerous to live in cities. Their deaths can be caused by cats, diseases, poisoned food and chemicals.

1.2.2 Understandable streetscape design for people

One of the most important urban street planning instrument is improving mobility access for all. Especially for ‘’soft’’ mobility modes like pedestrians, cyclists, and public transit, but also for cars and other motor vehicles (Rehan, 2012; Urban Street… 2016; El-Shimy et al., 2016; Jones et al., 2008). Although urban streets have usually limited space, it is important to develop safe and comfortable streets where people want to be and return. Good streets have people-friendly quality street elements like sidewalks, bike lanes and facilities, organized and safe street corners, crossings, curbs, medians, different attractions for example street vegetation, public art, cafe spaces, goods and services, and organized furniture like benches, lightning, trash receptacles, signage, bus shelters (Rehan, 2012; El-Shimy et al., 2016).

El-Shimy et al. (2016) in their research brought out that people of different ages should have various activity choices. The speed should be as humane and slow as possible and the pedestrians should be separated from vehicles to prevent safety issues. The tree canopies

should be used as shades which also refer to the multimodal benefit of trees. And the cultural heritage should be protected which makes the urban environment more attractive and economically beneficial (El-Shimy et al., 2016). Jones, et al. (2008) found that the movement to the destination should be with minimum disruption and seamless connection.

Overall it is important to create an understandable design for all: pedestrians, cyclists, public transport users, service vehicles (emergency services, waste, etc.) and other motor traffics and also habitats and vegetation.

- It helps to reduce the number of personal motor vehicles circulating reducing emissions and air pollution (Urban Street… 2016);
- It makes street spaces user perspective, human dimensional supporting healthier lifestyles and livable urban environment (El-Shimy et al., 2016);
- It is related to cultural and economical benefit- creates attractions while involving people in the streets (Urban Street… 2016; Rehan; Säumel et al., 2015; El-Shimy et al., 2016).

1.2.3 Recycled and low impact materials and technologies in construction

With modern technology, material variety, and recycling there are several options on which to choose in planning and building the streetscape. But what should be kept in mind when designing streets?

One option is to think about the material to use in pavings, furniture, and other elements. It is best to use low impact natural materials that are produced as near as possible to building sites. For example to use high albedo and permeable pavements like photocatalytic cement (Rehan, 2012; Farhadi et al., 2019). Or choosing for building the car roads materials made of warm-mix asphalt, not hot-mix asphalt. It reduces the level of energy consumption and improves builders working conditions because it is produced at a lower temperature. It takes less energy and doesn't expose heat and fumes that much. Asphalt made of Bio-binders is another component to keep in mind choosing the asphalt. Bio-binders, also known as biopolymer is made from natural resources and are fully biodegradable. They are cost-effective and have good thermal stability (Sustainable road… 2015). Rehan (2012) in his study brought an example of recycled landscape element- tree grate manufactured from recycled scrap metal and durable cast iron. The choice of recycling is endless. You can

recycle metal, stone materials, wood, plastic, etc. For example, also reclaimed asphalt pavements, recycled concrete aggregate, products derived from coal-burning in coal plants (fly ash, boiler slag) can be all used again to produce the pavements (Sustainable road… 2015).

Furthermore, using local planting and urban tolerant species could be more durable in the long-term (Urban Design… 2016; Säumel et al., 2015).

With modern technology, we could use more cost effective and environmentally friendly solutions. For example, replacing halide lamps with LED and mercury vapor lamps is one step for more efficient energy use. Another choice is installing full cut-off light fixtures to reduce light pollution. Also, stormwater management technologies, electric cars, and vehicles, and solar panels are modern tools for a sustainable environment (Rehan, 2012). It can:

- have environmental and economical benefits- improves the city's energy and resource efficiency (Urban Design… 2016; Rehan 2012)
- reduce urban heat effects (Rehan 2012; Farhadi et al, 2019)
- reduce light pollution and glare (Rehan 2012)

1.2.3.1 Stormwater management

The water that hits our street after a rainfall or snow melting causes soil erosion, flooding, makes sewers overflow and leads pollutants and unnatural elements to water streams. Stormwater management helps to reduce runoff from streets to landscape strips, permeable pavement, lawns and other sites that absorbs the water and filters it before it gets to streams, rivers, lakes, or wetlands (Why Is Stormwater… 2018). Providing stormwater management with bioswales, rain gardens, stormwater planters, and pervious pavements are energy-efficient and good for the environment (Urban Street… 2013; Urban Street… 2016, Säumel et al., 2015; Rehan, 2012). The goal of all types of green areas is to collect water close where it falls and treat it with soils and plant material.

Stormwater management can:

- reduce irrigation needs (Urban Street… 2016);

- improve water quality (Ottosen et al, 2019; Weber et al., 2013; Sashua-Bar et al, 2010a!; Rehan, 2012; Urban Street… 2013) by collecting pollutants in the water (Säumel et al., 2015);

- detrain stormwater flows and reduce stormwater columns (Urban Street… 2016).

Bioswales

In the streets stormwater runoff is captured, treated, and infiltrated by bioswales, which are vegetated, shallow, landscaped depressions. They're usually sized to handle the water quality, often known as the "first flush," which is the first and often most contaminated amount of water that results from a storm. The most successful form of green infrastructure facility for slowing runoff velocity and cleansing water while recharging the underlying groundwater table is bioswales. They can be combined with medians, cul-de-sacs, bulb outs, and other public space or traffic calming measures due to their flexible siting requirements. (Urban Street… 2013)

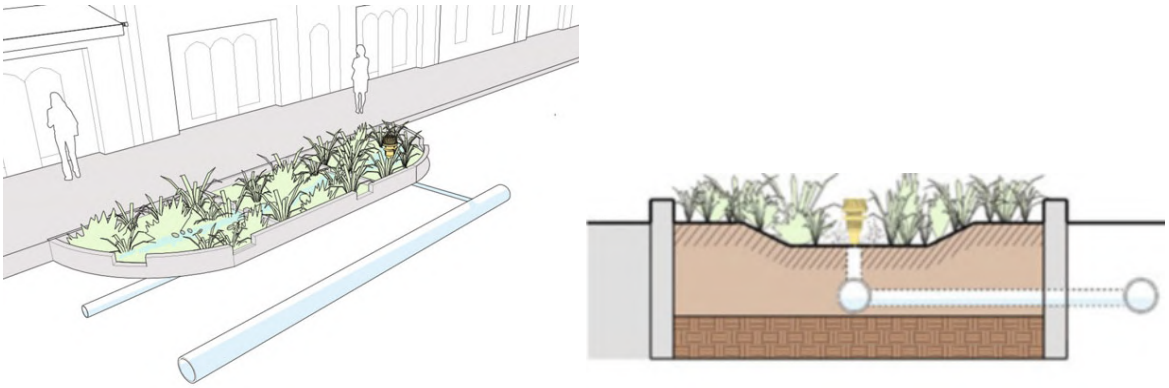
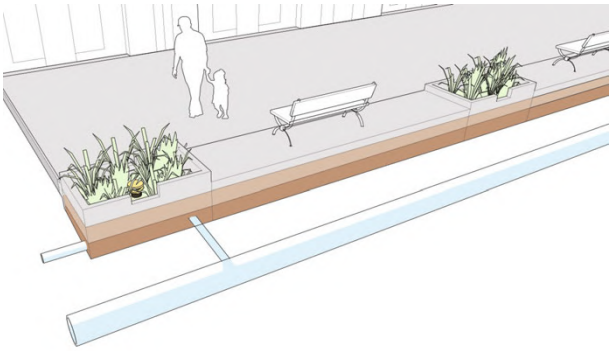


Figure 1 and 2. Illustrative perspective and section of a bioswale. (Urban Street… 2013).

Bioswales require special soil mixture. It should consist of a maximum 5% clay content. The soil mixture should pass 12-25 cm of rain water per hour. Bioswales should have a slight slope that moves water along the surface. It is important to allow sediments and pollutants to settle out. Furthermore bioswales mostly should have built in overflow to manage storms larger than the water quantity event. (Urban Street… 2013) See figures 1 and 2.

Stormwater planters

Hardedged stormwater management facilities with an impermeable base are referred to as flow-through planters. Flow into planters handle water by allowing runoff to soak through the soil matrix and filter into an underdrain system, making them ideal for infiltration in preclusive or high-density urban areas. (Urban Street… 2013)



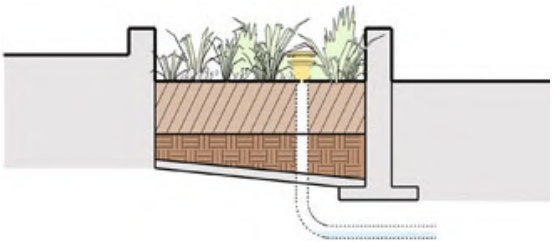


Figure 3 and 4. Illustrative perspective and section of a stormwater planter. (Urban Street… 2013).

Flow-through planters can be placed on non-infiltration areas, such as hard paved street segments. Planters always require an overflow pipe. (Urban Street… 2013) See figures 3 and 4.

Pervious pavements

Where landscape-based stormwater management techniques are limited or insufficient, pervious pavement effectively handles, detains, and infiltrates stormwater runoff. Sidewalks, street furniture areas, and entire roadways may all benefit from pervious pavements (or just their parking lane or gutter strip portions). Treatments should be adapted to the environment and maintenance resources available. This kind of pavement should drain the water within 48 hours. (Urban Street… 2013) See figures 5 and 6.

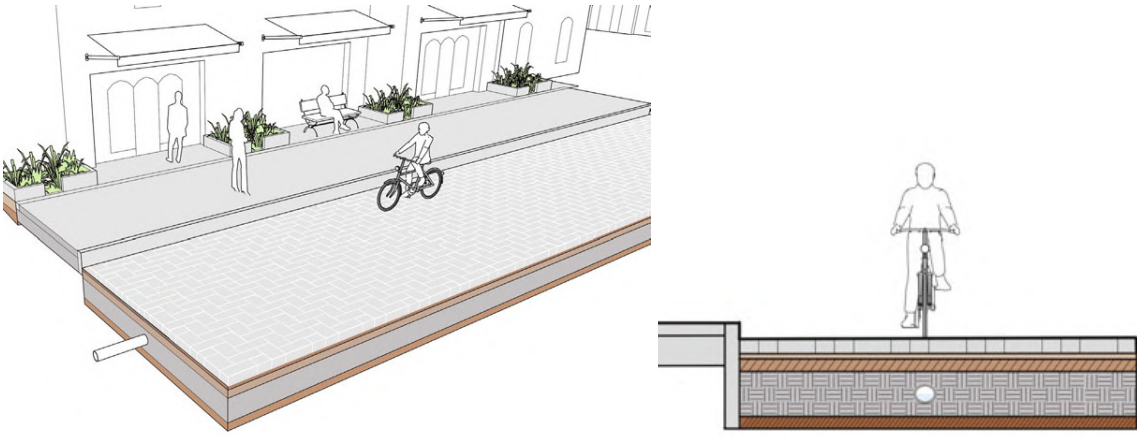


Figure 5 and 6. Illustrative perspective and section of a pervious pavement. (Urban Street… 2013).

1.3 Examples of sustainable reconstructed streets

1.3.1 Jaktgatan/ Lövängsgatan, Norra, Stockholm, Sweden street project

Jaktgatan/ Lövängsgatan is a modern street project in Sweden. Designed by AJ Landskap in 2004-2014, built in 2014-2015. The street is designed for movement at different speeds and ages. It also provides pleasant spaces for staying due to shelters and diverse and lush vegetation. The street contains a 6.5 meters wide green path asymmetrical within the street. Greeneries and previous pavements handle the stormwater management on the street. Overall they call it safe, car free urban space, where the footway is a large part of the street.

Wooden platforms and seating is located within the greenery. Wooden platforms are tied together by narrow wooden footbridges on the ground. These platforms and footbridges add playful addition and a tranquil setting for an urban environment where it is pleasant to live and stay. Trees, shrubs and perennials favor biodiversity and raise ecological, visual and social value to the street. Planting areas are framed by granite walls and trees are planted along the both sides of the driving area. Some parts of the streets are coated with cobblestone with walkways of large concrete stones. For comfortable movement of cyclists, the traffic lane is made of accessible flat cobblestone. This street project is contributing to the overall sustainability of the district and strengthens both social and ecological values. It creates a healthier way of living, encouraging citizens to walk, meet and enjoy themselves and greeneries. (Holmes, 2018) See figures 7-10.

To promote biodiversity, this project used methods of wild-growing vegetation. To create a multi-leveled and diverse green atmosphere, it has used a variety of plants with varying heights and appearances. In addition, various deciduous trees were used, which tolerate air pollution better than conifers.

Figures 7-10. Jaktgatan/ Lövängsgatan street. Authors: Kasper Dudzik, Helena Wahlman and AJ Landskap (Holmes, 2018).

1.3.2 Vestenpark Hendrik Speecqvest, Mechelen Belgium

OMGEVING landscape architects with a partnership of D+A Consult designed, technical detailed and supervised the Vesternpark Hendrik Speecqvest construction. It was constructed in 2015-2019 in a total area of 1.67 ha. It cost 2 580 000 €.

It all started when OMGEVING AND Mint drew up a concept drawing for AWV (Road and Traffic Agency) in 2012. The design is ingenious because a big part of the park is situated on the roof of an underground car park. They had an opportunity to reduce the transit need in the area due to neighbour streets and created an urban boulevard named Hendrik Speecqvest on a northern part and the Vesternpark on the southern part. Spacious continuous park structure for cyclists and public transport has become a new identity for the city space. With this intervention the balance between circulation and accommodation is equal. The urban heating effect is softened by green infrastructure due what the city is more climate adaptive. Perennials, grasses and deciduous trees and bushes are creating an atmosphere for people and an ecologically reasonable environment in the street. To enhance biodiversity, this project has used methods of wild-growing vegetation. To create a multi-leveled and diverse green atmosphere, it has used various plants of varying height and character. In addition, various deciduous trees, which tolerate air pollution better than conifers, were used.

The project is smartly done because they organized car parking underground not in the streets. There is room for 352 in this underground park. Within the construction of the parking roof they made it possible to plant large trees there, making the substructure unnoticeable in the park. They had the capacity to remain 2x2 lanes for cars, however they expect that in 2022 the right hand lanes will be converted to bus lanes. For pedestrians the design with sitting walls and planting areas are creating logical walking routes and guides the users, creating safe and legible intersections. Boules court and picnic benches are creating attraction points for tranquillity and relaxation. The perennials and shrubs are creating a lushious vibe there, which in spring is enriched with lightning. (Vestenpark…2020) See figures 11-13.

Figures 11-13. Vestenpark street (Vestenpark…2020).

1.3.3 Georgia Street, Indianapolis, Indiana, United States

Georgia Street was designed by landscape architecture and urban design bureau RATIO IN 2010. In 2012 they constructed 4645 square meters of street. This project team considered essential to create livable cities not only humane options for mobility but also provision of ecological services to express vitality of a city. Georgia Street provides both pedestrian priority space, but also urban forestry and green infrastructure.

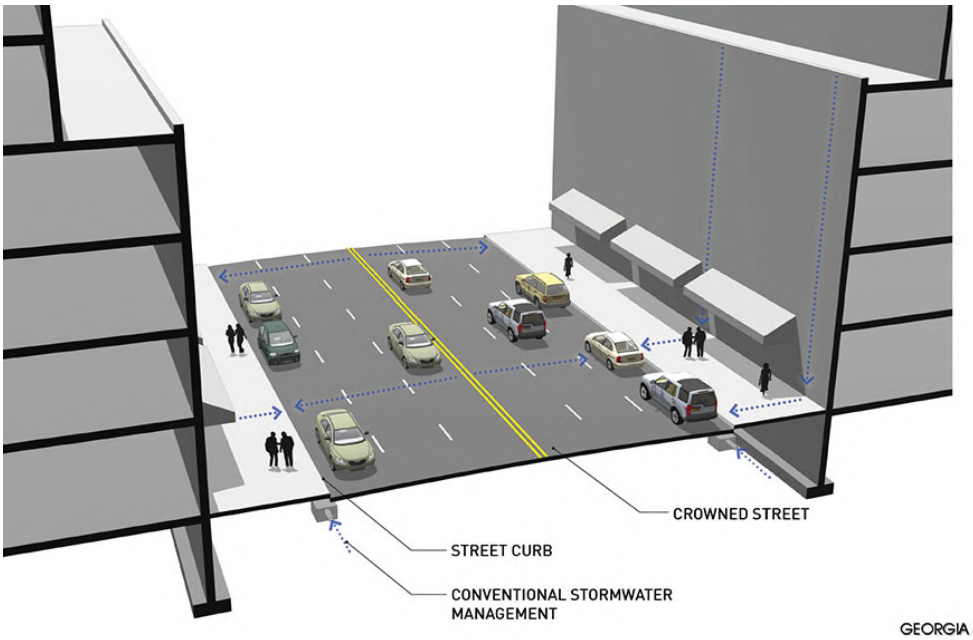
They had three main design principles: advocating for pedestrian priority, providing social infrastructure and designing for the invisible

First one main point was to create humane mobility options- curbless, pedestrian-first environment was designed with a sharing space with vehicular traffic. Four traffic lanes for cars were reduced to one travel lane in each direction with limited on-street parking. The remaining ways became accessible for modes of non-vehicular movement.

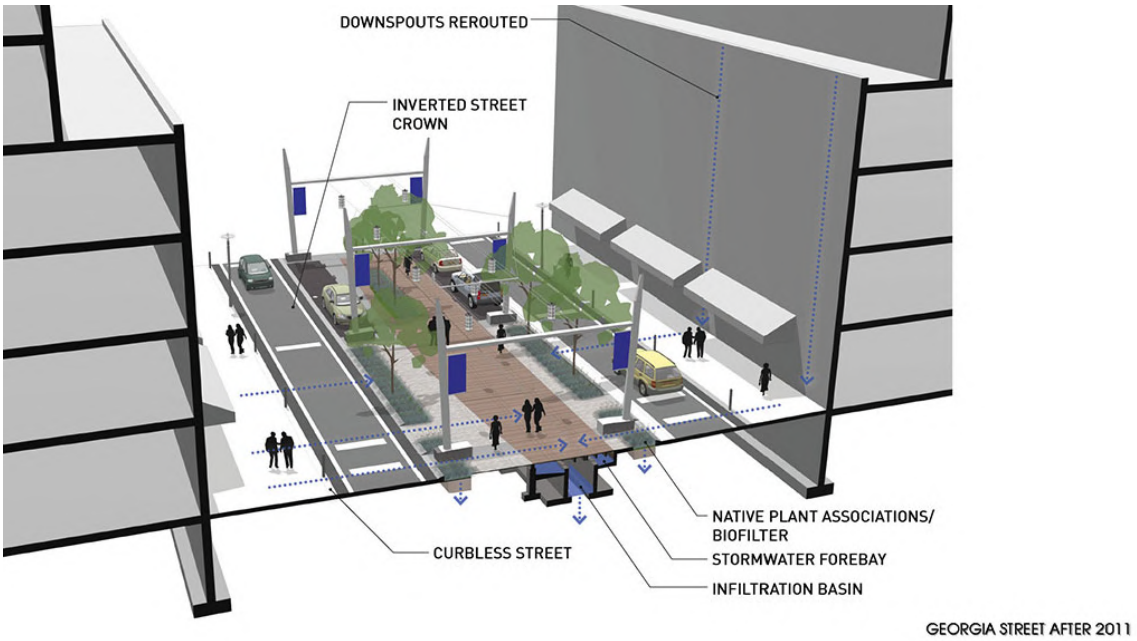
The second principle was to enhance public space by providing social infrastructure. The room from cars was designed to be a wide broadwalk with many amenities including cafes, solar shades, retail kiosks, historic markers and public art.

The third principle- designing for the invisible meant integrating ecological services in the street. They planned the movement of rainwater, permeable covers and irrigation cistern for rainwater management.

Trees were a vital part of designing healthy urban ecology. Large caliper trees were planted along the street. They concentrated on choosing native plant associations for natural and long lasting plantations. (Georgia Street… 2020) See figures 14-17.



GEORGIA STREET PRIOR TO 2011



Figures 14-17. Georgia street. Image Credits: RATIO; Susan Fleck; Jason Lavengood (Georgia Street… 2020).

1.3.4 Distrito Valle del Campestre (DVC) Streetscape

Landscape Architects of Grain Collective and Architect Arista projected a new concept of street in Monterrey, Mexico to alleviate traffic safety.

In 2013, community members of a local organization initiated a series of urban and mobility studies and continued to collaborate with landscape and urban designers, mobility and traffic engineers, local government, public service agencies, private developers, environmental groups and community residents to work forward to safer and sustainable streets. The new vision emphasized pedestrian safety while prioritizing environmental resiliency. For that they created a master plan with a series of pedestrian corridors

connected with residential and commercial areas, fragmented with green spaces to calm traffic.

For environmental sustainability they planned to reduce flood damage and air pollution by incorporating green infrastructure, expanding habitat corridors and addressing stormwater management through urban day-lighting. Several pocket parks, greenways and educational nodes promote opportunities for outdoor attraction. Luscious perennials, grasses and deciduous trees are creating an atmosphere for people and ecological environment in the street. (DVC… 2019) This project has used various plants with different height and character to create a multi leveled and diverse green atmosphere. And also used various deciduous trees and bushes which tolerates air pollution better than conifers. See figures 18-19.


Figures 18-19. DVC Streetscape (DVC… 2019).

1.3.5 Reidi street reconstruction project in Tallinn, Estonia

The Reidi street road project has been one of the largest street design projects of recent times in Estonia, Tallinn. The construction of Reidi street started in July 2018, and was completed in November 2019. The goal was to harmonize car traffic between Pirita and the city center and to improve the quality of life in Kadriorg.

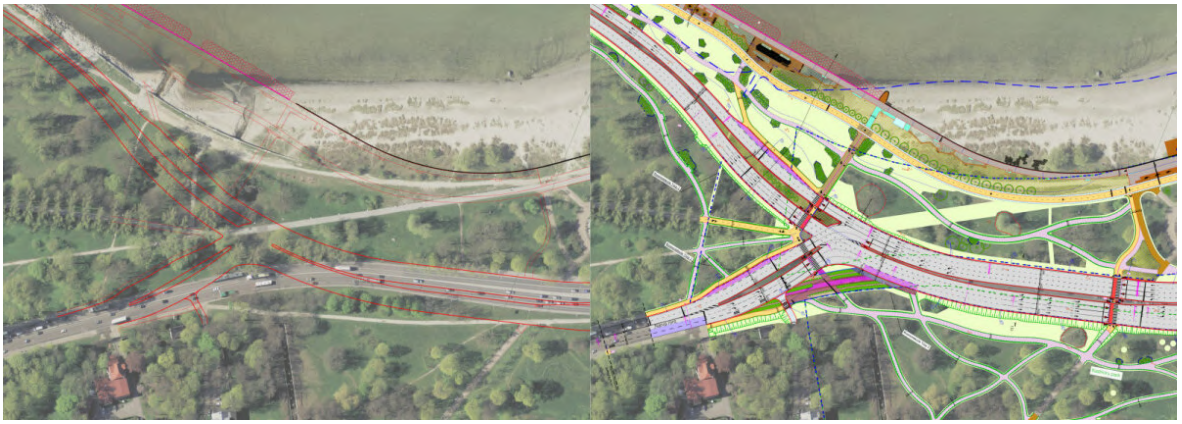
During the construction, new road sections were built and the existing road sections were reconstructed, including pedestrian and light traffic roads in the total extent of almost 14 kilometers, of which the new Reidi street was 1.93 kilometers. New and reconstructed light traffic roads and footpaths were built on a total extent of 10.5 kilometers. Also, a beach

promenade with recreation areas was built. Reidi tee was built by Verston Ehitus OÜ and KMG Inseneriehituse AS and projected by K-Projekt AS and Novarc Group AS and Kersti Lootus, Kiur Lootus, Kadri Uusen. What is interesting is that it was built partially at the sea by 7,500 square meters (Gnadenteich, 2019).

Construction work included road construction, construction of urban and coastal promenades, utility networks (incl. water supply and sewerage, rainwater collector, rainwater pumping, street lighting, electricity supply, communication equipment, traffic control systems, gas supply, heat supply etc.) and landscaping. The Reidi tee project cost almost 43 million euros.

The construction of Reidi street will make it possible to bring heavy traffic and, to a large extent, car traffic out of the Kadriorg residential area. In this way, the noise and pollution load in surrounding areas will be significantly reduced. The construction of the Reidi street will enable the construction of public transport routes on Narva street, which will create an uninterrupted smooth movement for public transport, the aim of which is to improve public transportation time of arrival. The area continues to have a recreational and leisure function, only in significantly better conditions (Reidi tee… 2019). See figures 20-22.

The planners used a variety of plants of varying heights and personalities to create a multi-leveled and diverse green atmosphere. Trees that are tolerant of urban environments, as well as some native trees, were used. Furthermore, different deciduous trees, which tolerate air pollution better than conifers, were used.



Figures 20-21. On the left Ingliranna orthophoto with projected street lines, on the right the whole project (K-Projekt).

Figures 22. Photo of Reidi street (Teder, M.).

1.3.6 Roosi street reconstruction project in Tartu, Estonia

On September 28, 2016, Roosi Street was reopened in Tartu. Reconstruction of Roosi Street began in the summer of 2015. The reconstruction of the street was based on the Roosi Street design concept "Memory Meters" and a sketch project that envisaged a complete street design solution from Kaarsilla to the Estonian National Museum building in Raadi. See figure 23. A 3.5-meter-wide pedestrian and cycle road was built on the street. Furthermore, landscape architects designed planters and landscape strips with wild vegetation, bus waiting pavilions, and benches to the street. Seeing this kind of new and innovative street design in Estonia, the public reacted rather positively and the street was well received. Diverse green atmosphere patches were created with various plants of varying heights and appearances. The project used urban tolerant deciduous trees in design. The reconstruction of Roosi Street was carried out by Asfaldigrupp OÜ, planned by Tinter-Projekt OÜ, and designed by OÜ Kino maastikuarhitektid. The total cost of the street reconstruction was 2.6 million euros. (Rekonstrueeritud Roosi… 2016)

Figure 23. Roosi street (Tunnel, T.).

The modern solution has prompted the whole surroundings to be tidied up. Buildings and gardens are being reconstructed and new development is progressing. Unfortunately, there is one problem left on the street - parking. Although parking posts are restricting parking, road users find places where these posts do not exist and park on landscape stips. (Roosi tänav - kaks aastat...) See figures 24 and 25.

Figures 24 and 25. Illustration of the parking problem. On the right visible the parking posts. On the left visible the green areas destroyed by the cars parking. (Roosi tänav - kaks aastat...).

Another unofficial streetside biodiversity project in Veeriku where the overall visual impression is improved and biodiversity increased by letting vegetation grow spontaneously. See figures 26 and 27.

Figures 26 and 27. Näituse street landscape strip and railway crossing in Veeriku district. (Tamm, R., 2020).

1.4 Case study area: Tartu

Tartu city is quite compact within its structure. The average distance to peripheral areas is on average 3-5 km. The Tartu transport development plan found that most movement takes place between home, work, school, trade, and service establishments.

There are 17 districts in Tartu. The population is high in Annelinn, Ülejõe, Karlova, Tammelinn, Kesklinn (city center), Ropka, Veeriku, and Raadi-Kruusamäe. The population density is quite low in Maarjamõisa which is affected by the clinic of the University of Tartu. It takes a large part of the territory which increases the demand for movement for students and workers. The population density is lowest in Ihaste. The average population density is in Vaksali, Supilinn, Variku, Jaamamõisa, Ränilinn, Tähtvere, and Ropka industrial area.

Tartu city center is the main public and business service offer. The main shopping and grocery stores are located in the city center, Ränilinn, and Annelinn. Most of the

workplaces are located in the city center, Ropka industrial area, Maarjamõisa, Ränilinn and Tähtvere district.

The average distance from home to work is 3,8 km (2-5 km for most people). The most optimal distances to work are for residents who live in the city center, Vaksali, and Karlova district. Overall statistics say that 33,8% goes to work on foot, 25% by public transport, 38,2% by car and 3% by bicycle. Moreover, the average length from educational facilities to homes is 1,56-3,36 km. To schools and kindergartens, 38,1% goes by foot, 29% by car, 27,9% by public transport, and 5,4% by bicycle. The movement by car depends on the parents' movement needs.

1.4.1 Karlova district

The Karlova district has the potential to have more pedestrian-friendly streets. This is due to the fact that the distances to the surrounding areas are optimal. The average radius distance from the center to the periphery is only 0.7 km. Karlova, as previously stated, has a high population density. A large part of Karlova has been designated as a building area of environmental value as a result of the wooden architecture from the early twentieth century. The majority of the district's modern buildings were completed in the early 1910s, with some also completed in the 1920s.

Forselius School, Karlova School, Tartu Art College, Tartu Art School, Tartu I Music School, Helivõlu and Tartu Private School, private kindergartens Karoliine and Helika, and the Institute of Educational Sciences of the University of Tartu are all located in Karlova. (Karlova...)

1.4.2 Case study Sõbra street

Sõbra Street (Freundschaftstraße in German) is a street in Tartu. See figure 28. Its length is 1570 m. The street starts from Võru Street and ends at Siili Street. The street intersects with Kesk Street, Tähe Street, Linda Street, Salme Street, Kalevi Street, Raua Street, Nõva Street, Turu Street and Sassi Street (with Sassi Street only from the left). St. Alexander's Church is located by Sõbra Street.

The average width of the street is 20 meters. There are growing birch tree lanes and there are quite wide grass patches separating the pedestrian path. In some segments there are cars parking on both sides of the street. Overall there is quite wide space for cars and there

are many cars driving because of that. From a pedestrian point of view there is too high speed and noise level due to that. There are lacking interest points and places to see and visit on the street.

Figure 28. Google street view of Sõbra street (Google Maps).

1.4.3 Case study Tähe street

Tähe Street is a 4.1 km long street in Tartu. See figure 29. It starts at the crossroads of Riia and Võru streets, runs through the Karlova and Ropka districts and reaches the city limits in the Ropka industrial district.

Tähe street intersect with Väike-Tähe Street, Päeva Street, Koidu Street, Pargi Street, Lootuse Street, Eha Street, L. Tolstoi Street, Õnne Street, Kuu Street, Vaba Street, Sõbra Street, Saekoja Street, Nigula Street, Purde Street, Alevi Street, Tehase Street, Kuru Street, again Tehase Street, Teguri Street, Harbor Railway, Ropka Street, Aardla Street, Sirbi Street, Ropkamõisa Street, Sepa Street, Ringtee street.

The name of the street was Sternstrasse in German. The cornerstone of the Estonian Corporation building on Tähe Street was laid on April 13, 1885, and on August 20, 1886, the opening of the house was celebrated. The construction plan of the house was prepared by the architect of the University of Tartu Reinhold Guleke, who also designed the Livonia convent of the corporation, the gymnasium on Magasini Street, the New Anatomical Museum and the building of Tartu Brewery. The house was located on the edge of the city

at that time, a park was planted around it and a garden with a lawn and a ring road in front of the house was built.

The width of Tähe street is from 12- 15 meters, some parts even 20. There are many interest points on the street, such as cafeterias and local businesses like shops, hairdressers etc. On the streets there are growing linden tree lines on both sides of the street. In some segments it is possible to park on the streets, some do not. Overall the space has quite a good opportunity to be more people centered because of the businesses and the background of the street. It is known as the heart of Karlova.

Figure 29. Google street view of Tähe street (Google Maps).

1.4.4 Case study Lev Tolstoi street

Lev Tolstoi Street is a street in Karlova, Tartu. See figure 30. It starts on Tähe Street and ends on Kalevi Street, on the other side of which continues as Jõe Street. The length of the street is 335 meters. The street is named after the Russian writer Lev Tolstoi.

The width of this street is 12 meters. It feels quite narrow because of the linearly going high houses on the side of the road. There are also growing pruned lindends on both sides of the street. Huge part of the streets have taken car parking. Pedestrians only have narrow side paths on both sides of the street. Despide of the narrow space, cars have two way traffic there.

Figure 30. Google street view of Lev Tolstoi street (Google Maps).

1.4.2 Street planning principles in Tartu

Tartu city transport development plan 2012-2020 is practical research mostly for the city government which guides planning Tartu transportation and movement. According to this paper, the vision of Tartu transport is a city with friendly, safe, sustainable, and smooth traffic with everybody. Tartu has many visible positive results to show as being sustainable. For example, Tartu is quite a pedestrian and cycle friendly city, and using soft transportation modes is gaining popularity. Also, Tartu is using modern technologies in public transportation vehicles, and due to that environmental pollution has decreased.

The land use planning and transport politics goals are to plan the movement according to the needs of people. With this, they have set a goal to reduce the average walking time from 16 to 15 minutes, average cycling time from 19 to 17 minutes, and average public transportation trip length from 28 to 25 minutes. However, they set a goal to increase the average time length for car users from 16 to 18 minutes. It means that distances are quite optimal and possible to walk, another question is how comfortable is to use slower movement modes.

Another goal is to raise the quality and accessibility, reducing traffic congestions and providing a smooth movement. They want to increase comfort and safety by renovating

pedestrian and cycle roads, also crossings providing easy accessibility.

The paper has also brought out some elements that could go to the sustainable building materials and technologies category. They set goals to use good quality pavements and to modernize street lightning using renewable energies and technologies.

For motor vehicles and street layout, they named that bus stops should be located in pockets and there shouldn't be any opportunities for cars to park or stop on the main streets.

The goals for cycle paths were that they should not be on the same level as the motorway, the path should be separated from the carriageway at least with a 0,5 m separation strip. Traffic calming and bicycle parking and storage places should be provided and an elaborated bicycle network.

For pedestrians, the needs of disabled people should be considered and according to equipment provided. The lightning on the pedestrian crossing needs to be excellent. Furthermore, they hope that in a bigger plan these methods change traffic behavior and awareness of cyclists and pedestrians.

1.5 Technical measures

According to the design norms and requirements of the Road Regulation, the width of a safe single-lane pedestrian road is at least 0.75 meters, two-lane 1.5 meters and 3-lane 2.25 meters. According to the same regulation, the width of one lane cycle path must be at least 1 meter, the width of 2 lanes 2 meters and the width of 3 lanes at least 3 meters.

According to the regulation, the maximum dimensions of a passenger car are 1.8 meters and those of a bus are 2.55 meters. The car's boundary dimensions are designed among other things for parking lots and outdoor areas. The boundary dimensions of the bus are used to design lane widths, lane extensions on curves, bus stops. (Tallinna Linnavalitsuse…1999)

2 METHODOLOGY

The main research question is how to plan and design livable and sustainable streets in case of Tartu. Main principles were generated from theoretical input, interviews with nine experts were conducted to test the appropriateness of the principles, design concepts were created to test the principles on design, and expert feedback was combined to analyze the reliability of the design results. See figure 31.

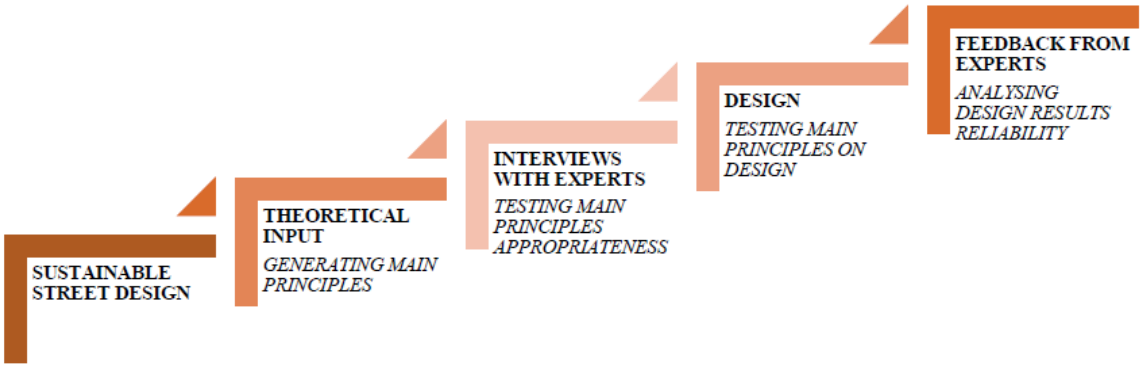


Figure 31. Methodology flowchart (Author, 2021).

2.1 Interviews

After collecting a theoretical base and main principles from literature review a qualitative research method was used to find the answer to the research questions. Semi-structured interviews were held where the respondents had to answer preset open-ended questions. The interview format was 7 of 8 times individual, one time with a group of two. Interviews were conducted once, in an average duration of 30 minutes, a few times up to an hour. Interviews had a base guide, which was a list of topics. Literature review was the basis for formulation of the interview topics with city planners, landscape architects and related experts. Interview guides served the useful purpose of exploring many respondents more systematically and comprehensively, as well as keeping the interview focused on the desired line of action. To ensure that the interview data is captured as effectively as possible, recordings of the interviews were saved among the researcher and the respondent. The recording of the interview allows the researcher to focus on the interview content and

verbal prompts, allowing the transcriptionist to create a "verbatim transcript" of the interview. (Jamshed, 2014)

Interviews took place in March of 2019. The interviewees were chosen randomly in thought they are familiar with Tartu city planning and street planning. The list of interviewees combined within a snowball method - interviewee recommended the possible interviewees. Nine people were interviewed. Five of them were from Tartu City Government: from the Departments of Architecture and Construction, Urban Economics, Urban Planning and Land Management and Engineering. Also the same discussion was held with the deputy mayor. Furthermore, a road engineer, and three landscape architects were interviewed. The aim was to find out the street planning perspectives from different stakeholders. The interviews were held via the web, due to the COVID situation.

After conducting the interviews, analysis of the results was done. Interviewees were classified according to their area of expertise: municipality expert (M in short), municipal engineer (ME in short), road engineer (RE in short), and landscape architect (LA in short). All the interviews were recorded, listened and written down to categorize the answers to topics. The topics were: what makes the street sustainable; green infrastructure and urban street: green infrastructure, biodiversity; people and urban street: people-centered space, non-motorized road user; technology and material in street planning: stormwater management, streetlightning, materials; street features: safe, durable, maintainable; how to achieve it?: pilot projects and tests, rising awareness, dividing streets and street space, cooperation and involvement, architectural competition and by problematic themes: ways of thinking, lack of space, pricing, car preference, regulations.

2.2 Design

After the interviews research design was held. The matter was to explore, identify and map the possibilities (Nijhuis, et al., 2020) of street design principles in Tartu, Karlova.

First of all the design principles were summarized from the interviews and literature review. The design principles were categorized in four topics: general focus points, urban nature - green infrastructure and biodiversity, understandable street design for people and recycled and low impact materials and technologies.

With this base of research the concept of sustainable street network was created, taking as an example of Karlova district. The concepts included three different street types - street

type A, street type B and street type C. Furthermore from each street type, example street segments were taken for more specific design. Section and plan design helped to visual the ideas from study.

2.3 Feedback questionnaire

A conclusional feedback questionnaire was created to analyze the results of the literature and interviews, as well as design principles. It was created to learn how experts in general respond to combined solutions from literature and all expert groups. The general conceptual design division of streets and all street type solutions were questioned to determine whether and how well the designs are based on the main sustainable design principles - green infrastructure on streets, people-oriented design on streets, and sustainable materials and technologies. The poll was designed for experts to answer the questions in about 20 minutes. All questions were graded on a scale of one to five, with one being completely disagreeing and five being completely in agreement. The poll was anonymous to avoid separation of experts preferences in design. In total seven interviewees from nine responded to the questionnaire. The results were analyzed in order to have a more in-depth discussion.

3 RESEARCH RESULTS

As mentioned earlier, interviewees were classified according to their area of expertise: municipality expert (M in short), municipal engineer (ME in short), road engineer (RE in short), and landscape architect (LA in short). View the full table of the interviews results in Appendix 1 Table of interview results (in English) or Appendix 2 Table of interview results (Eesti keeles).

Interviewees were asked what makes a street sustainable without any prior knowledge of the subject. Seven people from nine responded that streets should be built in a people point of view, where pedestrians and light traffic are privileged (M 1, 2, 3, 4 and LA 7, 8, 9). However other two interviewees also mentioned the importance of human perspective later in the interview. The subject was enhanced with various elements and features, such as the value of street characteristics, rest and interest points, and safe mobility. The responses of road engineers, on the other hand, were distinct from those of others. Their initial thoughts on sustainability revolved around street longevity, time tolerance, and low-maintenance requirements (ME 5 and RE 6). The importance of green spaces and landscaping were also mentioned (LA 7, 8, 9). The most notable response was that the sustainable street is a street where the processes of nature are exploited (LA9).

3.1 Topics

Further to the introductory question, the topics were divided into four categories: green infrastructure and biodiversity in an urban street; people's perspective in an urban street; material and technology used to construct the street; how to achieve sustainable streets; and current street planning and development issues.

3.1.1 Green infrastructure and biodiversity

Three times out of nine, the subject of heat issues and providing shade was brought up (M2, M4). The warm radiant sun and the expansive asphalt create precisely the problems that landscaping could alleviate. Greeneries have emotional value, according to one fascinating point of view (M2). Since we don't have much room in our current space, an interviewee from the municipality suggested that flower containers be used more

frequently (M4). An interviewee with an engineering background made a valid point: if we want to make more room for landscaping, we need to divert traffic somewhere else (ME5). It was assumed that landscape architects had clearer views on the subject. Since cities already have structure, the LA7 believes that the historic milieu influences the green structure on streets, such as whether high or low trees are acceptable. He mentioned that trees, shrubs and herbs should be combined. The LA8 also believed that diverse plantation choices were essential. The LA9 raised the point that, if possible, domestic plant species should be used because they are adapted to our climate. The main reasons for preferring trees on a street space were to provide shade, habitat, and to spread scents; however, trees are also suffering on streets due to vibration, heat, and water issues. The most interesting and distinct comment from her was that the classification of urban trees and landscaping should be reversed. The straightest tree should not be used to determine the healthiest tree, and the most valuable landscape should not be the one with the most intensively cared-for, mowed grass patches and the least biodiversity.

Two of the nine interviewees thought biodiversity was important in streets as well, however one said it isn't a focus for streets. Consequently, two people pointed out that ditches are the most diverse habitat environments, which corresponds to stormwater ditches (M4 and LA9).

3.1.2 Understandable street design for people

The responses varied on this topic, but the majority of interviewees agreed that the people in the street space makes the street so called living.

Four interviewees described how streets serve different functions (M1, M4, RE6, LA7): some have more intense traffic, such as Riia street in Tartu, while others have calm, even uncomfortable traffic situations that don't support cars as much, such as Tartu's old town. And it is not everywhere reasonable to plan just for people. An interviewee from the municipality (M2) believed that street furniture and the right attributes encourage people to go outside. He even brought along an example of how people like their toys, that are electric scooters and bikes. The M3 brought up a similar point, namely that resting places, also known as furniture, promote healthier lifestyles and encourage people to move. People-centered space was also a point of debate for the landscape architects. Interviewee LA7 specifically stated that the street should be a place where people can interact and share their experiences. A good people-centered street, according to another landscape

architect, has points of interest, businesses, and attractions. Again one interesting statement from interviewee LA9 was that a person wants to see another person in the street space without making any direct contact. People like passive observation and participation in life.

Eight participants considered that pedestrians are the most important whom to plan streets. The development of light mobility is the key for sustainable streets (M2). Also, the importance of cycle roads and planning separated space for them were mentioned by M2 and LA8 & LA9. Furthermore, LA7 stated that our climate is not supporting comfortable day-to-day movement, and another said that it is because our streets are out of hand (M3).

3.1.3 Recycled and low impact material and technologies in construction

The material and technology topic is divided into three subtopics: stormwater management, street lighting and materials.

Stormwater management received surprisingly a lot of feedback from interviewees. Some believe that innovative green stormwater solutions are not realistic yet (M1, M3, LA8) because we are lacking will, knowledge, space (M1, ME5) and understanding to develop them. Besides that, it would be realistic if we rebuilt the entire street network to create a large-scale system, but this is not achievable due to the costs (M1, LA8). Interviewees M1, LA9 were optimistic that new developments will be interested in nature based stormwater solutions. Rainwater issues, according to interviewees M2, M4 and ME5, are actively addressed, and a street is not designed without rainwater solution. They did, however, explain that they are not built without a pipe system, which is anyhow inevitable in our country. Interviewees M4, ME5, RE6 stated that the impregnation to the ground should be used whenever possible; however, there is a risk of ground freezing, which is why all systems must have a pipe. Three interviewees of nine also bring up the filter ditch topic, but two of them were rather skeptical about them. The interviewee M4 said that they are rather avoiding creating ditches because residents complain to the municipality that they are dangerous. Interviewee RE6 agreed that ditch is necessary if there is nowhere for the water to go, but he also stated that is not always operational. The LA9 interviewee was amazed that city dwellers are so soft and still prefered nature based rainwater systems. Also the road engineer (RE6) said that the normal water cycle is depending on it. Furthermore the interviewee LA9 was talking against interviewees M2, M4 and ME5 that pipelines that are perfectly functioning really can not handle all the rainwater, because the amount of water has increased and will continue to increase in the future. She implified

however the rain garden and ditch have the same result: they should be used to manage the water for the right ecological reasons.

Another significant feedback was received regarding sustainable materials. Three interviewees expressed in confidence that we use as much local product as possible, such as sand, gravel, concrete, concrete pavers, cobblestones, clinker, asphalt, metal and wooden furniture elements (M1 & ME5, LA7). However, interviewee M4 from the municipality assumed that nearly half of the pavers are actually ordered abroad and the asphalt components are also ordered from abroad which raises the question of whether asphalt is a truly sustainable material and whether we actually prefer local pavers. According to the M1 interviewee, our country does not have enough capacity to produce everything ourselves and we have not tested the products long enough to ensure that they are long lasting. The M2 interviewee thought that our policy does not favor expensive solutions and assumed that local materials are more expensive. An engineer (RE6) gave an interesting solution example for road marking. Tartu road planning company mixed green color into the asphalt so that it would distinguish the cycle path from pedestrians. They claim that in the long term this solution is much more sustainable, because it eliminates the need for road marking and future marking maintenance. He also reminded us that materials should be chosen for service load - high traffic and heavy vehicles and some pavers are not long-term sustainable. Even so, he would say that their company prefers pavers whenever possible. He stated the issue that freezing destroys the pavement in our climate, which was also briefly mentioned by another engineer from the municipality. According to the interviewee LA8, landscape architect, concrete and asphalt simply crumbles from time to time. She also added that it would be beneficial for the designers and constructors to have universal guidance that shows the environmental footprint of various products. She added that she would recommend using granite to construct curbstones. Yes, it is slightly more expensive, but it also lasts longer. Landscape architect, an interviewee LA9, confirmed that it is important to use as little hard cover as possible and only when absolutely essential.

Slightly less, but a fair amount of attention received the street lightning topic. The M1 interviewee, as did interviewee M3 and M4 from the municipality, assured that Tartu is moving in the right direction in terms of replacing old natrium bulbs with more energy-efficient alternatives. Interviewee M1 also mentioned that Tartu has experimented dimming solutions in urban landscapes. Even then, it is not used as much because it is expensive. She also emphasized the importance of only lighting the areas that are

absolutely necessary in order to avoid light pollution. She used the example of park luminaires that are not covered on top and thus light the sky. Tartu city engineer gave another thought to keep in mind - if planning a street, then electrical cables can be routed underground. As a result, maintenance costs are reduced, and the street's appearance improves. According to a landscape architect (M7), we overexpose our urban environment. His solution was to use as few lights as possible and try to create a system that illuminated the streets over one at night.

3.1.4 Characteristics of streets

The main characteristics of the street should be that it is safe, durable, and easy to maintain. Five of the nine people stated that the streets should be safe (M3, M4, ME5, LA7, LA8. People with political backgrounds mentioned that reasonable speed and adequate lighting would provide safety. Two landscape architects, on the other hand, devised the most inventive method of making streets safe: people on the streets. When there are enough people on the streets, people want to spend more time there. The existence of many people makes the environment safe, because there are enough people guarding and witnessing the moment. It can also be described as people would have their own control over the environment.

Durability was another characteristic. Three of the nine people mentioned that the materials should be time-resistant (M1, RE6, LA8). However, two people pointed out that freezing weakens materials (ME5, LA7).

When it comes to maintenance, ME5 and LA7 shared a thought that street space should allow for snow in the winter, making the street easier to maintain. RE6 and LA8 advocated for low-maintenance streets, arguing that investing in durable and long-lasting materials with cutting-edge technology will keep future costs under control. LA9 held a divisive view that we over-maintain the city's green spaces, incurring unnecessary costs.

3.1.5 How to achieve sustainable streets?

How can these streets be created in Estonia? Different people had different points of view. The main keywords that would describe how it would be possible were testing technologies and solutions with pilot projects, raising overall awareness, street division, cooperation and involvement, and through architectural competitions.

For starters, pilot projects and small-scale testing were a popular response. Three members of the municipality and a road engineer agreed that we needed to try out different sustainable solutions and see how they worked. The M1 suggested that we look for Scandinavian examples and test them to see if they work. The M3, on the other hand, provided a different perspective. He mentioned that we should pay attention to the changes while street constructions are held. He brought an example of Riia-Vaksali construction, in which a significant portion of the road is narrowed down for traffic. He claimed that the congestions in the rush hour are nearly, if not exactly the same as they were before. So here is a thought: do we really need so much space on Riia Street? The fourth municipality member emphasized that it is most beneficial when we practice solutions in the area so that residents can experience them for themselves.

Moreover, some people believe that raising general awareness is necessary (M1, M4, ME5, LA9). Interviewers M1 and LA9 believed it could be accomplished through the media. Landscape architect also suggested doing it through boards and seminars. A member of the municipality recommended that it be done through projects (M4). A landscape architect (LA7) suggested that new ideas should be convincing to local authorities, and that we should share the significance of the findings with them.

Eight out of nine had viewpoints on dividing streets or street space. Interviewee M1 had the impression that we require hierarchical street space division. M2 agreed that redistribution of street space is inevitable and needed. According to the M3, the street space should be divided so that the light traffic users would feel comfortable. Both interviewees with engineering backgrounds believed that streets should be divided into functions such as heavy traffic and light traffic, or main street, access street, and local street. Depending on this, thresholds, reversers, or landscaping can be used to reduce the speed of the respective street. Landscape architect, interviewee LA8, stated that while we now have a street hierarchy based on vehicle traffic, we are missing divisions based on ecology and landscaping, as well as the social aspect. According to interviewee LA9, the room should be able to be used in a variety of ways, including temporary events, cars, and other everyday activities. As a result, the division could be multifunctional.

Five interviewees mentioned collaboration or people involvement. If the second interviewee (M2) thought we should involve the community in the thinking, interview

subjects M3, ME5, and LA7 thought we should involve other experts in the process, such as landscape architects and electrical engineers. The M4 from the municipality stated that they are deciding whether or not to involve the landscape architect in the process. The road engineer believes that landscape architects are very useful for these types of projects and that they would like to use them more frequently. He explained that the goal of an engineer is to create projects that are simple, reliable, functional, feasible, and maintainable. Landscape architects, on the other hand, provide design input. The landscape designer (LA7) said the same thing as the road engineer, but he also mentioned the importance of the lighting engineer.

A designer from municipality and landscape architect found that architectural competitions are excellent ways to design streets. First, they will provide a broader range of solutions, implying that the options are broader (M1). Second, it would be ideal for designing important streets as a result of this (LA8).

3.1.6 Problematic themes

The conclusion of the interviews contained the problematic themes of street planning. Ways of thinking, lack of space, pricing, car preference and regulations were the main concerning topics that our street planning is against now.
There were thoughts that the time we live in, as well as the ideology and culture of the time, do not favor widespread and volatile street experimentation (M2). According to the fourth interviewee (M4), ditches are dangerous to city dwellers. LA9 interviewee added that she has heard that oak and apple trees are also considered dangerous - not preferred things on streets, whether they drop on cars or cyclists fall into ditches. In any case, she stated that these fictitious problems are absurd, and that people should remain responsible for themselves. In addition, cities should not over protect the city environment. A road engineer raised an interesting point about how contractors are sometimes not interested in environmental solutions as much as they are in making money. This implies that their goal is to work on a fast track, with cheaper products, which according to Interviewee LA8 is also incorrect. She referred to it as unprofessional behavior.

Another inevitable issue is the issue of space. Cities are clearly quite dense, already developed (M4), and street space is quite narrow. The utility networks are one main thing that takes up a lot of space on the streets. Something unseen by the naked eye is taking up

so much space (M1). Sprawling is unavoidable, and reprocessing them is both costly and financially unwise (RE6). The former Tähtvere parish, according to a municipal engineer, has recently gained some space in Tartu. However, the new developments are minor. They continue to plan as narrow and compact streets as possible while ignoring the creation of wide boulevards and a pleasant ecologically reasonable environment.

Seven out of nine people said that, in the end, the design is determined by price, and the cheapest solutions and options in planning processes win (Interviewee M1, M2, M4, ME5, RE6, LA7, LA8). However, two people, one with engineering (ME6) and one with landscape architectural (LA8) backgrounds, were certain that convincing clients to invest more in the beginning and making it clear that this will cost less in the future maintenance should be practiced more and more in our country, because quality always wins.

The car theme was also introduced. Some have stated that at this time, the vote of car enthusiasts is loud. One person believed that because we are car-oriented, there was nothing to do (LA7). We have opportunities, we are comfortable, and we take the advantage because of our climate (M3, LA7, LA8). One person stated that the streets should not be used for parking; instead, people should use their own land, parking lot, or parking house. Nonetheless, Interviewee LA9 stated that political forces who believe the car is fundamental are in the minority in her opinion.

Regulations were one of the last mentioned factors that hampered our planning and design solutions. Four of the nine respondents stated that political decisions determine what is preferred on the street and what functions the street should serve (M1, M3, LA7, LA8).

4 DESIGN

4.1 Design principles derived from literature and interviews

4.1.1 General focus points

1. pedestrian and cycle opportunities
2. urban nature
3. rainwater management

Support social, economic and environmental performances of the city. See chapter 1.1.

Design legit, safe, easy to maintain, comfortable, inclusive, resilient, long-lasting, multimodal, attractive streets without any visual clutter. See chapter 1.1.

Improve the issues of air quality, noise pollution, health and safety, water management, microclimate, energy consumption. See chapter 1.1.

4.1.2 Green infrastructure and biodiversity

Principles concerning green infrastructure and biodiversity developed from chapter 1.2.1:

- Plan wild-growing vegetation to foster biodiversity
- Use elements like trees, alleys, landscape strips, planters, shrubs, stormwater greeneries, flower beds, green roofs.
- Use mainly deciduous trees, because they tolerate pollution better than coniferous
- Use native urban tolerant local plants species.

Trees: European Alder, *Alnus glutinosa* (sanglepp); Silver Birch, *Betula pendula* (arukask); European oak, *Quercus robur* (harilik tamm); Swedish Whitebeam, *Sorbus intermedia* (pooppuu); European White Elm, *Ulmus laevis* (künnapuu); European Mountain Ash, *Sorbus aucuparia* (harilik pihlakas); Norway Maple, *Acer platanoides* (harilik vaher).

- Use urban tolerant tree species.

European Linden, *Tilia cordata* (harilik pärn); Poplar, *Populus* (pappel), Larch, *Larix* (lehis); Chestnut, *Castanea* (hobukastan), *Alnus nigra.*

- Use trampling resistant plant species.

Plantain, *Plantago* (teeleht); yarrow, *Achillea millefolium* (harilik raudrohi); dandelion, *Taraxacum* (võilill); annual meadow grass, *Poa annua* (murunurmikas); silverweed *Argentina anserina* (hanijalg); white clover, *Trifolium repens* (valge ristik); fragrant chamomile, *Matricaria chamomilla* (lõhnav kummel).

- Use common bushes in Tartu city.

Crataegus monogyna, Lonicera xylosteum, Swida sanguinea, Cotoneaster integerrimus, Viburnum opulus, Syringa L., Berberis vulgaris, Ribes alpinum, Euonymus europaeus, Thuja occidentalis and Buxus sempervirens

Principles concerning green infrastructure and biodiversity developed from chapter 3.1.1 and Appendix 1 or 2.

- Provide shade with trees.
- Use large flower containers where landscaping is not possible.
- Make room for vegetation - divert traffic somewhere else.
- Search into the historical milieu of the place and find out what kind of trees or bushes are common there.
- Combine vegetation for a more diverse ecosystem.
- Use domestic plant species.

4.1.3 Understandable street design for people

Principles concerning understandable street design for people developed from chapter 1.2.2:

- Improve mobility access for all.
- Slow down the speed where possible
- Separate the pedestrians from vehicles where possible.
- Use elements like sidewalks, bike lanes, facilities, organized and safe street corners, curbs, medians, attractions, street vegetation, public art, cafe spaces, goods and services, furniture (benches, lightning, trash receptacles, signage, bus shelters).
- Average walking time should be 15 minutes, cycling time should be 17 minutes, public transportation length should be 25 minutes and average time length for car users should be 18 minutes.
- Design bus stops into pockets.
- Cycle paths should not be in the same level as motorways - use at least 0,5 m

separation strip.

- Provide traffic calming, bicycle parking and storage places.
- Concentrate on safe and disruptional curbless pedestrian-first environment and crossings.
- Plan at least a 3.5 meters wide pedestrian and cycle road.
- Propose underground parking or parking houses if possible.
- Limit on-street parking.
- Reduce the transit need and move it up to neighbourhood access streets if possible.
- Reduce traffic lanes from four to one travel lane in each direction if possible. Use the other lanes for non-vehicular movement.

Principles concerning understandable street design for people developed from chapter 3.1.2 and Appendix 1 or 2:

- Plan streets from people's point of view, where pedestrians and light traffic are privileged.
- Divide streets to heavy and light traffic or main, access and local streets and privilege pedestrian on local and light traffic streets
- Use street furniture and attributes to make the street space attractive.
- Provide room for ‘’toys’’ - electric scooters and bikes.
- Design a space where people can interact and share experiences.
- Streets must have points of interests, businesses and attractions.
- Separate cycle roads from other movements.

4.1.4 Recycled and low impact materials and technologies in construction

Principles concerning recycled and low impact materials and technologies in construction developed from chapter 1.2.3 and 1.2.3.1:

- Plan stormwater management.
- Plan elements like bioswales, rain gardens, stormwater planters or/ and pervious pavements.
- Use photocatalytic cement.
- Use warm-mix asphalt not hot-mix asphalt or asphalts made of bio-binders.
- Find recycled street elements like recycled metal tree grates, wooden benches.
- Use LED and mercury vapor lamps.

- Install full cut-off light fixtures.
- Support electric cars and vehicles.
- Use a solar panel where possible.
- Plan wooden platforms and footbridges to add playful addition and to tranquil the setting.
- Use granite, cobblestone where there is less movement, larger concrete stones for walkways.
- Use flat cobblestone for cycle traffic late.

Principles concerning recycled and low impact materials and technologies in construction developed from chapter 3.1.3 and Appendix 1 or 2.

- Design longlasting, time tolerant and low-maintenance roads.
- Green stormwater solutions are not realistic yet, because the designs are local.
- Rebuild a bigger scale street network for large scale stormwater management.
- Use reasonable solutions that aren't too expensive.
- Use pipe designing rainwater solutions because of the freezing.
- Provide impregnation to the ground where possible.
- Use local sand, gravel, concrete, concrete pavers, cobblestones, clinker, asphalt, metal and wooden furniture.
- Mix green color to cycle path asphalt to distinguish the paths - no need for extra street marking.
- Choose materials according to the service load.
- Prefer pavers where possible.
- Use granite to construct curbstones - lasts longer.
- Use energy efficient light solutions - LED.
- Consider dimming solutions where possible, but not too many.
- Lumminarie only the important spots (not the sky, bushes, dwellers houses).
- Plan electrical cables underground - less maintenance and visual clutter.
- Create a system that illuminates one by one at night.

4.2 Design

4.2.1 Concept of sustainable street network in Karlova district

During the course of the project, a conceptual plan and design for the Karlova district's streets were created. See figure 32. This work primarily focuses on creating people-centered streets, highlighting a diverse green structure, and listing material selection recommendations to support sustainable design. The work does not delve deeply into engineering technical solutions.

The entire plan would entail reducing and redirecting car traffic in the Karlova district in order to make room for a more humane and environmentally friendly environment. The plan is to divert a larger flow of traffic around Karlova, leaving only a few traffic passage streets in the district (green segment). Both blue and orange colored types of streets still have car access, but the idea is that residents only use them to get to their homes. These streets are referred to as yard or calm traffic areas.

It is planned to use plant communities within the biodiversity concept on the green structures located on the streets to create a richer and more diverse street nature. Existing trees in good condition will be preserved. The bush front will be supplemented if possible.

Street type C, also known as blue street type, is concerned with ecological stormwater solutions. These are typically downhill streets. Stormwater solutions are also used in other types of streets. That’s because they work better when they are planned in a bigger scale street network.

The proportion of asphalt on the pavement has been kept to a minimum on all types of streets, and if possible, an alternative concrete stone, paving stone, or wooden boardwalk has been used.

With this approach, the Karlova district could become a buzzing, people-centered district where people spend time outside and the streets are greener and thus more visually appealing.

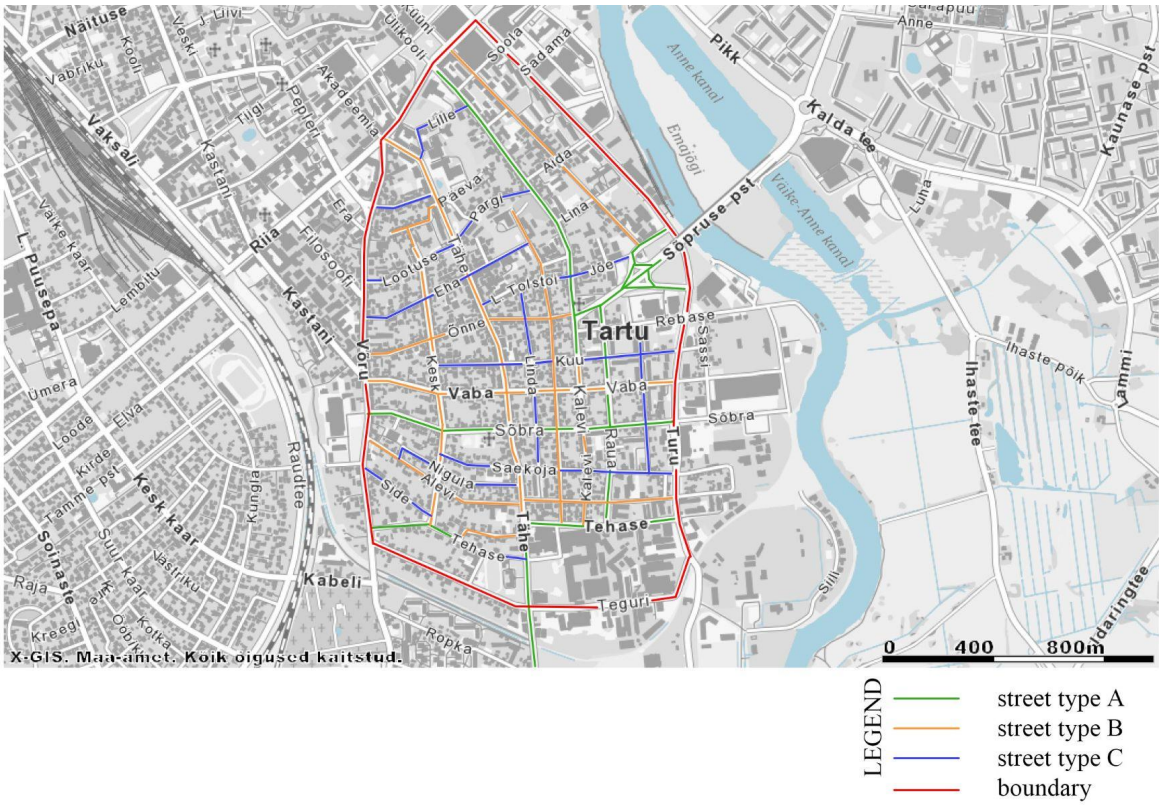


Figure 32. Concept of street type classification designing Karlova street network, Tartu (Google Maps; Author, 2021).

4.2.2 Street type A

The conceptual plan and section see on figure 33. The primary purpose of street type A is to serve as the main streets through which light traffic, as well as car and bus traffic, can pass through the Karlova district. With an average diameter of 20 meters, these are Karlova's widest streets. Street space is divided so that light road users, cars, and greenery all have equal space and a role in the street.

It is planned to plant wild grasses there, as well as save existing birches and improve shrubs and trees in the context of green structure and biodiversity. Keeping the existing adult trees provides shade for humans as well as additional habitat for insects, animals, and birds. To create variety in tree species, add common oaks or maples where possible. Sweet currants, lilacs, and honeysuckle can be used to enliven the bush front, providing food and shade for animal species as well as senses and visual stimulation for humans.

In terms of people-centredness, pedestrians have a nearly five-meter walking space and cyclists three meters for two-way traffic. A comfortable, functional, and inviting street

space could be created in such dimensions. A green zone at least one to two meters wide is also planned to separate light road users from car traffic. There is a two-way car road for car and bus traffic, with a top speed of 30 km per hour. This speed would reduce the overall speed of car drivers while creating a calmer and safer cognitive speed for light road users. However, to demonstrate that light road users are preferred on the street, various types of pavement could be used to illustrate that their route is as unite and smooth as possible and free of major distractions. Higher uniform platforms for pedestrians (bumpers) could be built at intersections to create a realistic cognitive situation in which pedestrians and cyclists have priority. Parking on the street should be restricted, and a limited number of parking spaces with combined green structure should be placed on the right side of the road. Grass pavers could be used to cover the parking area.

On the street, bicycle parking lots, electric bike and scooter facilities, and street furniture could be used. Moreover, street art, cafes, local shops, and architecture could provide an interesting experience for pedestrians.

Ecological stormwater solutions such as rain gardens and permeable pavement could be used to control stormwater. To avoid the risk of freezing, all solutions have underground pipes. Permeable paving materials are intended for use on sidewalks, bus pockets, and car parking strips. The most environmentally friendly way to build curb roads is with long-lasting granite pavers. Furthermore, energy-efficient lighting solutions, with a focus on pedestrian and cycle road lighting, could be used. Wooden sidewalk platforms add a playful touch to the overall picture. To avoid annual pavement markings, painted asphalt could be used to mark cycle paths. The proportion of posts on the streets could theoretically be kept as low as possible, i.e. the streets should be marked in asphalt colors or with road markings. Luminaire cables could be underground, and metal posts, such as traffic light posts and street signs, should be used as little as possible to avoid visual clutter.

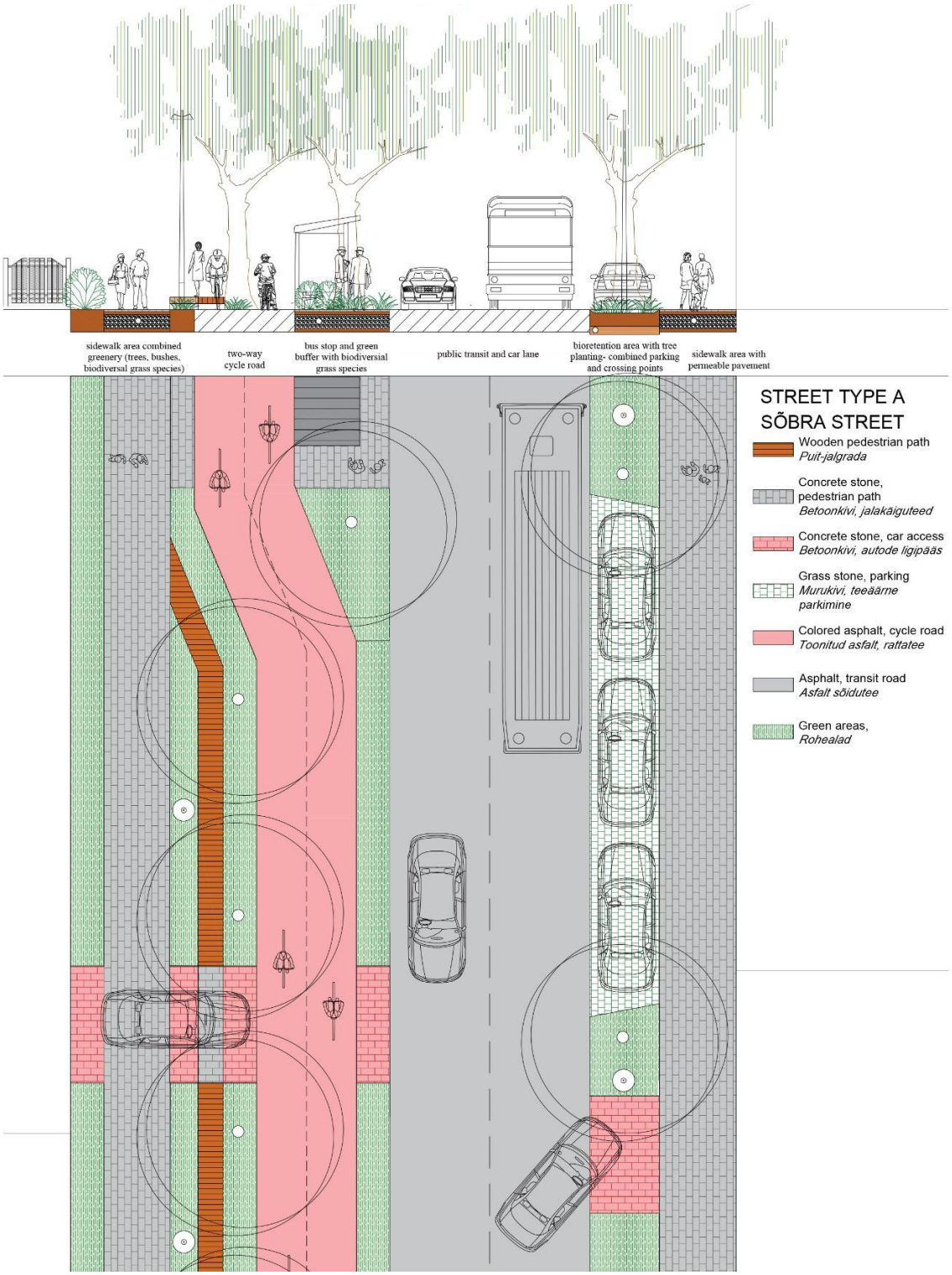


Figure 33. Conceptual section and plan segment of street type A (Author, 2021).

4.2.3 Street type B

The conceptual plan and section see on figure 34. The main objective of street type B is to be pedestrian and bicycle oriented, with green areas serving stormwater solutions and cars

and public transportation having as little and as uncomfortable space and rights on the streets as possible. These streets could be more intimate and thriving with activity. Spending time on the streets, in cafeterias, local shops, and cathering places is a positive step toward building a stronger community. Street space is divided with a diameter of 12-15 meters so that light road users and greenery have the most space and cars and public transportation have one way access through the streets.

Similarly, wild grasses are planned, as well as the preservation of existing lindens and the enhancement of shrubs and trees in the context of green structure and biodiversity. The retention of existing adult trees provides shade for humans as well as additional habitat for insects, animals, and birds. Sweet currants, lilacs, honeysuckle, and other common bushes in Tartu can be used to enliven the city's bush front, providing food and shade for animal species as well as sensory and visual stimulation for humans.

People would have access to 5.5 meters wide sidewalks. These streets, where possible, have outdoor cafeterias and local shops. Cyclists also have their own three-meter-wide two-way cycle path. In such dimensions, a comfortable, calm, and inviting street space could be created. Whereas it is impractical to separate the transit lane from the cycle lane at this width, pedestrians are separated from cyclists and cars by a 1.5-meter-wide green buffer. There is a one-way transit and car lane in concept, with a top speed of 20 km/h. This speed, like with the previous concept, would reduce the overall speed of car drivers while creating a calmer and safer cognitive speed for light road users. Parking on the street should be limited, and on the right side of the road, a limited number of parking spaces with combined greeneries and alley trees should be placed. The parking area could be covered with grass pavers.

The street, bicycle parking lots, electric bike and scooter facilities, and street furniture could all be used once more. Furthermore, pedestrians may find street art, cafes, local shops, and architecture to be interesting.

Stormwater management could be accomplished through the use of ecological stormwater solutions such as rain gardens and permeable pavement. All solutions have underground pipes to avoid the risk of freezing. To make the journey more interesting and educational, stormwater gardens or planters could be combined within the wide sidewalk. Raingardens could also be placed between parking lots where possible. Permeable paving materials are designed to be used on sidewalks and parking lots. Long-lasting granite pavers are the

most environmentally friendly way to build curb roads. Furthermore, energy-efficient lighting solutions could be used, with a focus on pedestrian and cycle road lighting.

To avoid the need for annual pavement markings, cycle paths could be marked with colored asphalt. The proportion of posts on the streets could theoretically be kept as low as possible by marking the streets in asphalt colors or with road markings. To avoid visual clutter, luminaire cables could be underground, and metal posts, such as traffic light posts and street signs, should be used as little as possible.

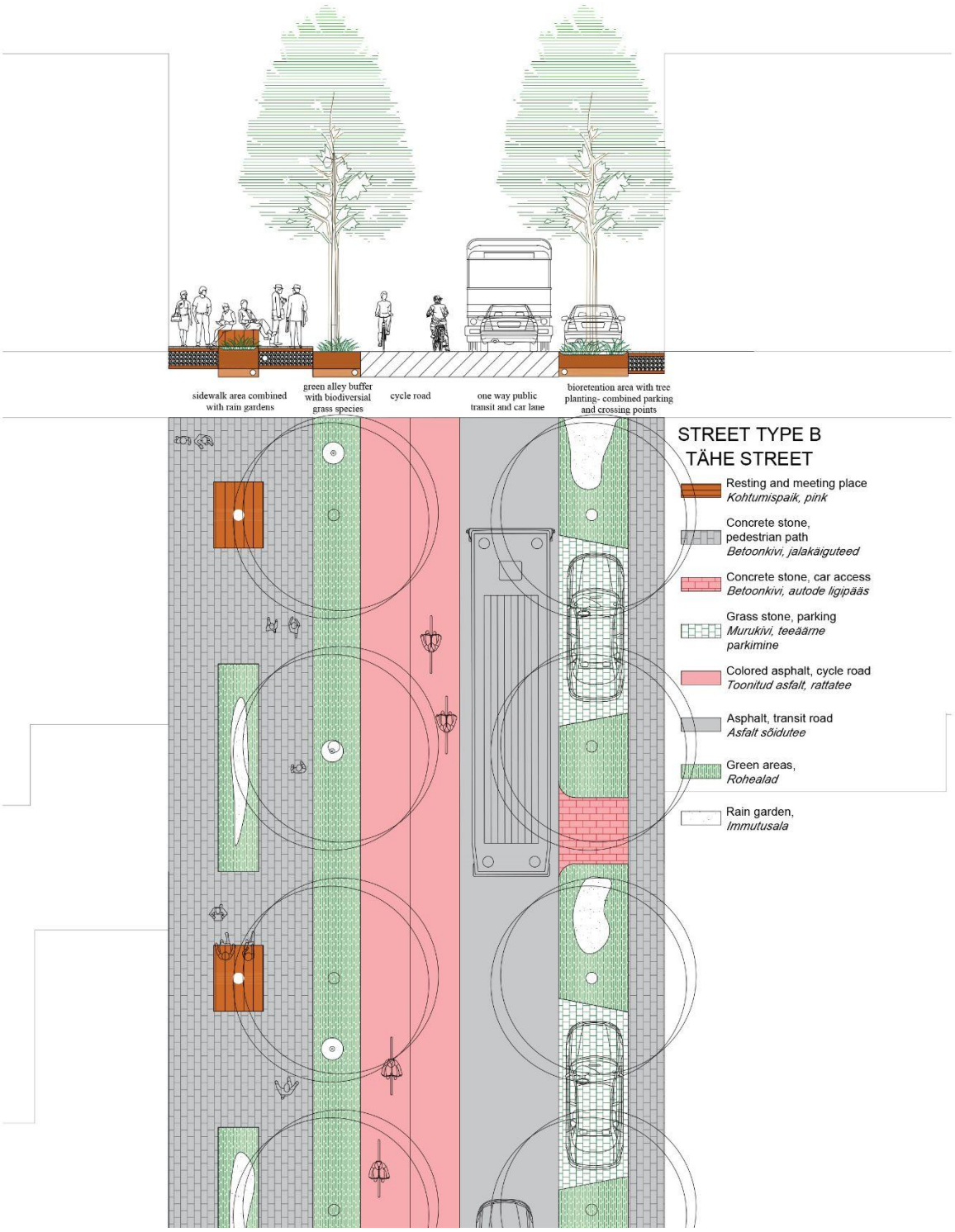


Figure 34. Conceptual section and plan segment of street type B (Author, 2021).

4.2.4 Street type C

The conceptual plan and section see on figure 35. The prime objective of street type C is to support environmental goals through larger-scale bioretention. These are the calmest and

narrowest streets in K arlova. They are no more than 12 meters wide. Their task is to lead massive amounts of stormwater. Because of that, the majority of the streets chosen are downhill. Streets A and B also have some bioretention areas to catch and guide water through the Karlova. Of course, these streets support light traffic as well.

Again, different heights of grasses, bushes, and trees are planned. Existing lindens will provide shade and habitat support, allowing biodiversity species to thrive. Several common bushes in Tartu can be used to enliven the city's bush front, providing food and shade for animal species as well as sensory and visual stimulation for humans.

A 2 meter wide sidewalk and a playful wooden pathway between rain gardens and lush grass vegetation are planned for people. Because these streets are mostly used for access to homes, there isn't much local activity on them. On the streets, there aren't many small shops and businesses. Furthermore, the street could have a yard area system where cars could travel at a maximum speed of 20 km per hour. The car access lane only allows residents to get to their homes. Cyclists will have priority and greater rights on this access lane than cars. There are also some parking spots combined with green areas and crossing points due to the relatively high demand for parking on the street. The parking area could be covered with grass pavers. There is also a 1.5 meter wide cycle lane on the streets.

Only 4 meters from side to side are covered with a hard surface on this type of street. Rain gardens and permeable pavements account for two-thirds of the street space. Permeable paving materials are designed to be used on sidewalks and parking lots. All solutions have underground pipes to avoid the risk of freezing. Rainwater is filtered by bioretention areas. Rain gardens combined with wooden pedestrian walkways will create an environment similar to hiking trails in nature.

Similarly to the previous street type, the most cost-effective option is to use high-quality granite curb road pavers. Furthermore, energy-efficient lighting solutions could be used, with a focus on pedestrian and cycle road lighting.

To avoid the need for annual pavement markings, cycle paths could be marked with painted asphalt. The proportion of posts on the streets could theoretically be kept as low as possible by marking the streets in asphalt colors or with road markings. To avoid visual clutter, luminaire cables could be underground, and metal posts should be used as little as possible.

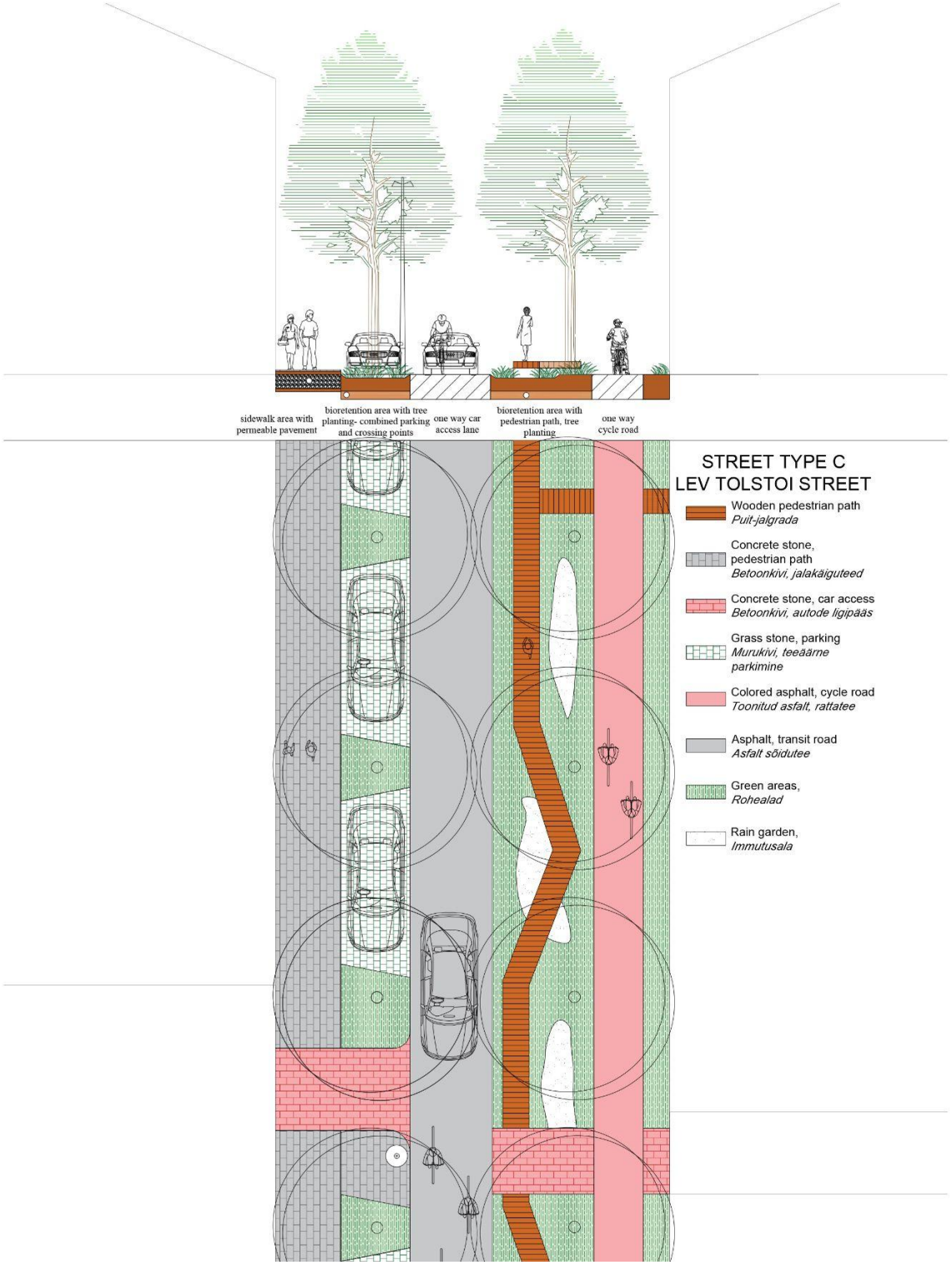


Figure 35. Conceptual section and plan segment of street type C (Author, 2021).

4.3 Results - feedback on design

The questionnaire was prepared in the form of a poll, allowing experts to provide feedback online whenever and wherever it was convenient for them. Seven interviewees completed the anonymous feedback survey. View the full feedback data on Appendix 3. Feedback data on design.

First, interviewees were introduced to the conceptual division of designed street types. The conceptual division of the streets supporting the sustainable urban street environment received an average of 3,6 points on a scale of 1-5 (Figure 36). The arguments were that because the beginning of the Sõpruse street is a transit road, it cannot be made green. Another questioned the function and durability of permeable pavements in our climate. The third explanation was that changing the traffic flow to one direction might increase traffic instead.

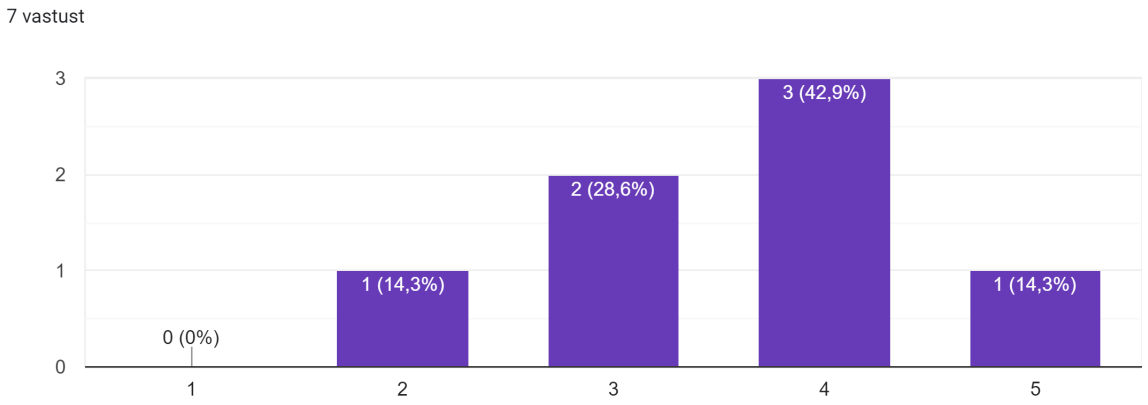


Figure 36. Overview results of the conceptual division of the streets supporting the sustainable urban street environment. 1- completely disagreeing; 5 - completely agreeing.

A unit diagram was created to summarize the answers and designs for each street type (See Figure 37). The concept of creating a people-centered street space received the most positive feedback. Estimates ranged from 4.1 to 4.3 for all street types. For the best traffic distribution, street type A received the highest rating (Appendix 3, Data 2). The average score for street types B and C was 4.1 (Appendix 3, Data 6 and Data 10). One individual inquired about the necessity of a wooden pathway in street types A and C. The surveyor explained that it is slippery in wet weather, requires special care, and is not as long-lasting

as asphalt. Another comment was that the preference of cyclists on street type C should be clearly visible on the road.

Green infrastructure that supports sustainable design received a positive response as well. Estimates for all street types ranged between 3.7 and 4.4. For the best green infrastructure planning, street type B received the highest rating (Appendix 3, Data 5). Street type C came in second with a 3.9 point average (Appendix 3, Data 9). The last street type A, on the other hand, was distinguished by only a few points, with an average of 3.7 points (Appendix 3, Data 1). The surveys were skeptical about how the underground pipes and cables are when the greenery is divided like that, and it was reminded that changing the street structure greener could be the basic problem.

In the sustainable design, the relationship between hard pavers and permeable pavement received an average of 3.3-3.7 points. Street type A received the most positive feedback, with an average of 3.7 points (Appendix 3, Data 3), followed by street type C with 3.6 points (Appendix 3, Data 11) and street type B with 3.3 points (Appendix 3, Data 7). The average grade was clarified because such a solution in street type A requires clarification on how to ensure stability and durability in cold cycles.

The ecological stormwater solutions used in design received the lowest marks. The average score ranged from 2.9 to 3.1, with street type C receiving the most points (Appendix 3, Data 12), street type B receiving 3 points (Appendix 3, Data 8), and street type A receiving 2.9 points (Appendix 3, Data 4). The unifying remark or question was whether or not the geology supports water filtration in the streets. In street type B, it was suggested that a green structure be placed between the cyclists and the car road.

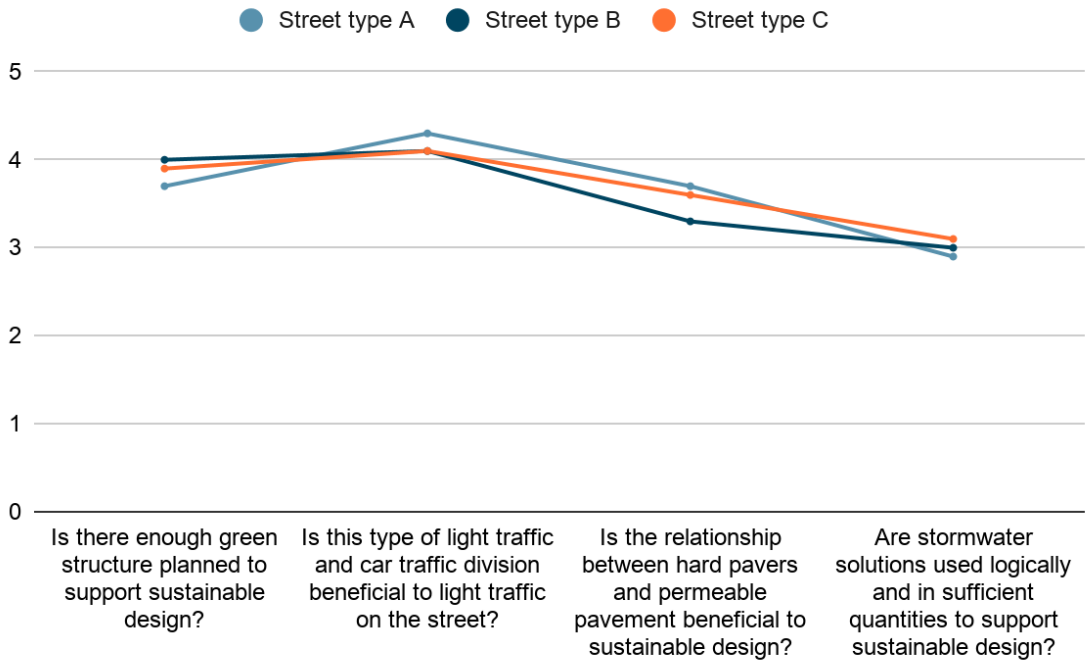


Figure 37. Overview results of the questions of sustainable urban street environment. 1- completely disagreeing; 5 - completely agreeing.

5 DISCUSSION

The aim of this research was to understand what makes a street sustainable. From the research there combined three main topics to study thoroughly:

- How to plan people-friendly, low-traffic streets that are also environmentally friendly?
- How to plan green infrastructure on streets to create environmentally friendly street space?
- How sustainable materials and technologies can be used in designing durable streets?
- If and how is it possible to use studied tools to design sustainable streets in Tartu, Estonia?

5.1 Sustainable streets

The people using the space, the design focusing on people's perspectives and pedestrian opportunities; the diverse green infrastructure increasing environmental performances and health and well-being; and the material choice and technologies used in construction are all answers to the general question of what makes a street sustainable. These topics found out to be the most important principles designing sustainable streets. It must not be forgotten that street planning is a complex process and the above principles only do not guarantee a well-planned street.

While all aspects of the literature appeared to be equally weighted, the interviewees primarily considered human focus and material choice to be the most important sustainability aspects. Because the topic of material selection in the design would have become too broad, it seemed appropriate as a landscape architect to plan the streets primarily in terms of human perspective and green structure, and to touch briefly on pavement materials. It was noticeable how the experts in their field all turned to certain topics. For example, landscape architects considered the surrounding and greenery as the basis of sustainability. Engineers saw the technical aspects and durability of materials as a solution to a sustainable street, and urban planners considered the mobility and light traffic aspects to be one of the most important points of reference when planning a sustainable street. It was refreshing to see the interest of different stakeholders to cowork and to help each other to plan and design and keep up with the times.

When designing the streets, the complexity of the whole process became clear - to design so that many sustainable technologies and solutions would be ensured. Fitting and satisfying all points of interest in a narrow, predetermined existing street space can be challenging. The conceptual division of the street space of the district on the principle of sustainability got quite a bit above average grade result, which meant that the design solution was so-so to rather sustainable. Since the design was based on all three principles, the feedback is rather positive. The main arguments were whether such a solution is still practical and durable in our climate, and that such a change in traffic management could instead increase traffic density. These arguments are true and will not be known until they are tested in our country. As the interviews showed, testing pilot projects and the reconstruction of smaller streets provides a good example of a basis for developing principles.

5.2 Understandable streetscape design for people

The interviews revealed that the most important is to build streets from a people point of view, where pedestrians and light traffic are privileged. It turned out that the main principle - people-friendly, low-traffic streets is the most fundamental for a sustainable and well-functioning urban environment.A safe and understandable street space for all users is the basis from the point of view of a user-friendly environment. In theory, this kind of planning would be one step toward a more sustainable street. It matters because unintentionally most of the world's society is very car-oriented, and it is critical to consider more sustainable options for our and the world's health. For further testing a design where the street plan was reorganized was made. All the street types were planned in a way that pedestrians and cyclists would have a wide and safe space to move. Within the Karlova district the goal was to reduce and redirect car traffic in the district. This was one method towards a more sustainable and living district. The response to the design from the interviewees was quite good, getting the average point of 4.1-4.3 from five. However there were some remarks about the plans. One remark was that changing the traffic flow to one direction might actually increase traffic. On one hand this is definitely true, but on another hand if we are not stepping out of our comfort zones we don’t know if this kind of solution might actually work and support society to spend more time on the streets and use alternative mobility options to cars. To find out if this hypothesis is really working, more thorough testing and scientific movement studies should be conducted. However, literature, expert opinion, design and design analysis have shown that this method is supported.

Going deeper into the literature and implementing the analysis input, the most important aspect of a sustainable and long-lasting street is to provide a complete space for light road users. Preference for light road users, as well as the provision of comfortable options for them, promotes a vibrant urban environment and environmentally friendly modes of transportation. On the other hand, the interviews echoed how our country is not yet ready for such modern solutions. It was said that we just are very car oriented at the moment and it is hard to change the perspective in a day from streets for cars to streets for people. They explained that our politics is not in the mindset yet. Although we are not so flexible, on the other hand, it is a matter of money. The reason is also the complexity of the work process. Planning a street requires the involvement of many different parties and, above all, a great deal of preliminary work to avoid major mistakes. However, a large number of interviewees supported the concept of an inclusive and vibrant street. Street type A received a positive response due to the distinctively wide buffer between pedestrians and vehicles in the form of a green structure. On the other hand, the street space was divided so that pedestrians and cyclists had their own space for movement.

On the design, on the street type B and C cyclists shared a common lane with cars. One note from feedback was that the preference of cyclists on the streets should be clearly visible on the road. This is also a very relevant point and can be resolved when really constructing this kind of street by street marking or traffic signs. A background idea was that if the whole district is with calm traffic where mostly pedestrians and cyclists are prefered then the image holds as a whole. It was also mentioned in the design that these types of streets are only access roads for cars, so cars would only use this road when absolutely necessary to get to their dwelling houses.

Designing space for people contains many aspects that might stay forgotten while designing streets. Yes, we want to create good street space, but where it is reasonable to design people friendly streets. Are the distances and opportunities to get there pleasant for people? To find out the answers to these for example Tartu is doing several movement studies and statistics to state main issues about light mobility and movement problems. This is helpful to study, because this is one step towards fixing mobility problems and planning alternative solutions.

Another thing that was brought out in literature and interviews and was conceptually designed on streets was the importance of attributes and points on streets. It was assured by

literature and interviewees, that interest points can help local businesses. Furthermore, they can be businesses themselves or streets or the architecture, or the modern technologies used (stormwater management, electrical scooters and bikes) or the green environment on it. Coming from the literature and interviews it felt that it is one refreshing point to keep in mind while planning the streets.

However then arises a question, which speed should this human perspective street have. It is logical that people prefer more stable and slow traffic. Where there is car speed higher than 30, the cars are automatically above people. It occurred that where possible, keep the speed as low as possible and when relevant then lose the traffic from streets at all. Again this point - if it is not tested we do not know whether it does harm or is good. From interviews this topic also got quite thorough discussion between several interviewees. The speed topic and division of street according to the speed would need more thorough investigation. Do we really need so much space for cars, or can we accept less and achieve a whole new perspective of common street space.

5.3 Green infrastructure and biodiversity

The significance of green spaces and landscaping was also mentioned in the general sustainability response. More thoroughly by landscape architects. The green structure on the streets improves both ecological and social performance by providing a pleasant visual and environment to be in. Each street was planned to have at least a third of its surface covered in greenery. This means that people would play a role, cars would play another, and greenery would play a third role. It varied, but in general, this segmentation was attempted. As previously stated, the planting selection was rather conceptually listed, so that each street type would have a variety of grass species, native bushes, and trees.

Bolder use of green structure is also in style nowadays. There are good examples from the Scandinavian countries like Sweden as well as in Tartu. The theory and interviews highlighted the importance of plant species selection. Above all, it should be based on choosing domestic species that can withstand urban conditions, because they are the most resilient in our climate. Another important point was to use existing greenery - why to take trees or shrubs down if they are still living okay. As people are not perfect then street trees or plants do not have to be perfect also. Why isn't a bit crooked tree as valuable as one strict tree when it isn’t dangerous for people? As there is also a biodiversity campaign in Tartu (Curated Biodiversity - Tartu 2024 - European Capital of Culture), the use of rich and

diverse flora also had a strong response. Examples of such rich green areas were also found in many study examples.

The main reason why the green structure does not have such a large place in the street space is the entire transit, and the predominance of cables and pipes on the streets. That main argument came up from literature and interviews. It is not the most preferable aspect, but with this the streets have to manage. Luckily it seems from literature and few interviewees mentioned that it is all solvable. However it needs a huge amount of resources to create this. It seems to be paradoxal circle while it isn't common in the world yet. Reconstructing the green area in the streets needs more thorough studies and investments to understand how they would fit into the streets with underground pipes and cables. It was also mentioned in the interviews and feedback, however this technical detail wasn't taken in mind in design. Studying more into it and finding solutions for more compact utility networks under the ground would reduce restrictions and common design styles for more innovative and modern solutions.

In addition, the green structure is useful because it acts as an ecological stormwater absorber if geology favors it. However it isn't as easy as planning general conception to the district and working with one solution. All streets are different, have different capacity and geological structure. It was remarked by interviewees to green structure planned in streets.

Green networks also play an important role in determining the well-being of light road users in the street space. It became clear that the green structure increases the well-being and health of people being in the streets. Furthermore it creates emotional value (M2). The perspective of how people take the street is largely up to the designed environment.

As the interviewee said it matters when it is done in the right ecological ways. This is one important influence on why the world is thinking of designing and planning things in the right way - for a better environment for ourselves, for our families, friends, acquaintances.

5.4 Recycled and low impact materials and technologies in construction

Another general state, strongly represented by engineers, but also by others was that streets must be long-lasting, time-tolerant, and low-maintenance. This is a very technical topic, so rather than getting too technical, it was only studied conceptually.

Solutions and variants ranged from hard pavement principles to recycled street furniture or lighting technologies. The main focus of the study was on the basic distribution of hard pavements in the street space. Various solutions for how to plan the streets were revealed. For example, it would be more practical to use paving stones with lower traffic density and vehicle load, but cyclists and vehicles still need asphalt for a more comfortable driving experience. In addition, there were various examples of asphalt production technologies, such as the creation of warm mix asphalt from the literature or the creation of recycled asphalt from old slippers from the interviewee. It turned out that the playing field in the production of coatings and products is wide and there are many possibilities. The reason why people are skeptical about new technologies is that their effectiveness has not been proven or it cannot be done or expediently in Estonia.

The concept used in the design was based on the principle that pedestrian paths would be covered with permeable concrete stones, parking spaces with grass stones and roadway asphalt and cycle paths painted with asphalt. These solutions are also intertwined with rainwater solutions, while also filtering rainwater. In the feedback form, the solutions received a slightly above average score. Surveyors were rather skeptical about the reality of such a pavement distribution in our climate and country, and about the expediency of making such big changes.

Pavement types and materials were shared in the design, as well as conceptual domestic urban tolerant planting options. This topic is important because it provides element-based technical measures for long-lasting and sustainable streets. Materials and technologies are the primary means of achieving technological sustainability. For example, if we talk about element longevity, it is important to discuss durable materials in the street concept. However, the results cannot reveal the true functionality and durability. For more detailed knowledge this topic needs to be studied and explained by engineers. The interviewees also mentioned in the feedback that this amount of permeable pavement might not work in our climate due to ground freezing. This could be studied more thoroughly to determine which alternative materials would actually work in our environment.

A wooden pathway was designed on street types A and C, focusing on more interesting walks for pedestrians. However, there was a comment to a design feedback in which the sustainability of wooden materials in the streets was questioned. The interviewee made a valid point in stating that it is likely to be slippery when wet, requires special care, and is not as long lasting as asphalt. This is an excellent place to think about and study. Right now, we prefer hard pavement (asphalt and concrete stones), which, in the long run, visually deteriorates and requires replacement also. How come nature paths, such as those in bogs, are covered with wooden pathways? Why can't we try to use them in a city setting? Yes, it requires more care and attention, but it adds an emotional and natural touch to the street space. It could be studied more thoroughly to see if this type of nature landscaping fits into the urban environment and how it affects the urban image and environmental performance.

Ecological stormwater solutions were also studied as a separate part of stormwater solutions. The examples included exciting and innovative solutions for rain gardens, filtration ditches and rainwater containers. In the design, the work mainly dealt with rain gardens and stormwater container solutions. Although the interviews revealed that ecological stormwater solutions are not very popular here and they have not been tested much, these solutions were used in the design. Feedback was also rather skeptical, but street type C also received a positive response. Street type C was mostly concerned with storing rainwater into rainbeds, green areas and permeable pavements. However while in Estonian case this topic is not fully used and functioning then in literature this design principle is thoroughly invested.

How could more sustainable streets be created in Estonia? There may be different solutions. A few good examples emerged from the interviews, as well as from the literature. The topics of pilot projects and testing were constantly discussed during the interviews. Take, for example, the Autovabaduse Boulevard project in Tartu. By allowing people to use the entire street space for gathering and being in the summer, there was a surprisingly positive response. If, for example, there was more resentment before the project started, then people had a more positive experience during the project. More such projects and even more small-scale street changes could be created. Among other things like health benefits and car emissions guidance elsewhere, it also raises people’s awareness by raising their interest with such projects.

There is also a lack of ecological planning for stormwater in Estonia. All the solutions are working through pipes and canals. The interviewee gave an example of how the client did not agree to use ecological solutions because they were not popular at that time and their effectiveness was not guaranteed. There is a wealth of information in the literature on modern stormwater solutions and countries should be interested in using them. As the interviewee said, it is important that things are done for the right ecological reason. It is understandable that testing and putting resources on unreliable things isn't prefered, but this topic has huge potential in baltic states to grow and to be studied and tested.

Another thing that is crucial to state in mind - good streetspace can only be combined with different experts coworking. This paper lacks many technical details on construction and durability because at one point it was clear that some selection of study needs to be selected. The interviews showed the relevant point that different experts share different ideas and are there to remind aspects they are most common

SUMMARY

The streets form a large part of the urban space. Movement to school, work, or recreation is taking place inevitably along the streets. Unfortunately, much of the city's urban space is traffic-oriented and car-centric. However, for general public a completely common way of street raises the question: „How else could it be? Which street space is sustainable, functional and user-friendly?''

Following research was finding answers to main questions:

- How to plan people-friendly, low-traffic streets that are also environmentally friendly?
- How to plan green infrastructure on streets to create environmentally friendly street space?
- How sustainable materials and technologies can be used in designing durable streets?
- If and how is it possible to use studied tools to design sustainable streets in Tartu, Estonia?

In order to find an answer to the research question, a background study was prepared on the research, and then interviews and conclusions were conducted among experts in their field. The experts included landscape architects, road engineers and urban planners. As it was mentioned in the interview, larger and more complex solutions should be solved in a wider area. From that note, the designs were tested conceptually within the boundaries of the Karlova district in Tartu. Three types of street designs were created. First one focusing on human-centered planning, second one on ecological stormwater solutions and the third on functional passage for all users. Although all street types focused on a specific type, the aforementioned themes were combined in all solutions. In order to analyze the designs, a feedback form was sent to the experts, where they were asked to evaluate the prepared design.

The research found that the most important basis for planning and designing streets is people's point of view and their user comfort. Giving cars the right to drive fast and dominate the street does not make people feel good on the streets. However, by creating wide pedestrian corridors, green structures and smooth cycle paths for light traffic users

seems to promote light traffic on the streets. It turned out that the concept of a people-centered street space is the most supported, but the solutions may not be in line with the concept due to the current planning policy.

Another important aspect from the point of view of a user-friendly and sustainable environment is the planning and promotion of green structure and biodiversity. The results showed that diverse vegetation is considered important in street space. The mowed lawn area and the tree alley alone do not fulfill the function of this versatile vegetation. Therefore, the combination of woody plants with shrubs and wild herbs was tested in the design to create diverse vegetation with different heights.

The third key issue was material and technological sustainability – for example the pavement materials, or ecological stormwater solutions that would form a physically sustainable street space. The fact that the whole sustainable street space starts with its construction was confirmed. However, the background of sustainable materials differed in literature and research. It turned out that what is sustainable in other parts of the world may not be sustainable in Estonia because of opportunities and resources to produce them. Furthermore, ordering materials from elsewhere will ultimately increase the footprint of the material to the environment.

Ultimately, the aim of the work was to find principles that would support sustainable design. The hypothesis that the mental sustainability of streets is created by its users is as important as the constructive technological side of sustainability. The green structure also plays an important role in the streets, whether it is for health or to create a more pleasant and environmentally friendly environment.

These principles should be tested even more and in depth both in Tartu and elsewhere. There is potential for room for innovative change, the implementation of solutions requires only time and resources for planning, testing and implementation. Creating a people-centered street space is possible only if society supports and wants it. At the moment, we are rather supporting vehicle comfort but with good examples we can make the world a better place.

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APPENDIXES

Appendix 1. Table 1 - interviews results (in English)

Topic		What makes the street sustainable?	Green infrastructure and urban street		People and urban street	
			Green infrastructure	Biodiversity	People-centered space	Non-motorised road user
Inter-viewee	Background					
1 M1	municipality expert	Combination of users.		Monoculture is not a solution- biodiversity is. Not favored in public.	Streets serve different functions, depending on the street and needs.	
2 M2	municipality expert	Preference of people and the role of street attributes.	Helps against heat islands, provides shade and emotional value.		Street furniture invites people to be outside.	The goal is to prioritize in the following order: pedestrian, bicycle and then cars. The development of mobility is the key.
3 M3	municipality expert	Health - safety, mobility and availability of rest areas.			Resting places promote a healthy lifestyle.	The roads are not in order and do not favor light road users, but they are most important whom to plan streets
4 M4	municipality expert	Well-thought-through mobility for light road users.	Use of flower containers on streets where space is scarce. Important in terms of heat islands.	Not a focus point for streets. A lot of diversity in ditches.	Streets serve different functions.	The most important thing is good mobility for light road users.
5 ME5	municipality engineer	Should not decompose, easy to maintain, safe.	If some extra space is made for landscaping, car traffic must be directed elsewhere.			Intensive traffic and pedestrians don't go together, they need to be separated. Reconstructing streets doesn't bring people outside, they need things to play with (scooters etc) or other interests .

6 RE6	road engineer	Time-resistant and made of low-maintenance materials.				On access streets, light traffic could be comfortable to pedestrians, but on the other hand uncomfortable for cars.
7 LA7	landscape architect	People-centered with some green space that allows movement and communication.	The historic green structure determines the milieu - whether high or low trees are suitable for particular streets. The durability of the plants is important (linden is popular). Trees, shrubs and herbs could be combined.		A space that allows people to experience and communicate. The people-centered space is, for example, the Old Town - car traffic is as inconvenient as possible. Karlova has potential to become one.	Allowing movement- our climate is not supporting it.
8 LA8	landscape architect	A space designed for people where there is a balance between people, landscaping, stormwater solutions, driving opportunities and social opportunities.	Trees are important, grasses aren't less important.		Points of interest, businesses and attractions are also economically viable.	SUPPORTING MOBILITY - People would choose to cycle, use public transport or prefer to walk. There must be points of interest along the way.
9 LA9	landscape architect	A space that is set up from the point of view of pedestrians and cyclists. A street where the processes of nature are exploited.	Rather use domestic species. The city tree must provide shade, provide habitat and spreads scences. The city has vibration, heat and water issues - many plants cannot tolerate it. If possible, prefer existing trees, not take them down. Concepts and regulations of urban landscaping and classification of landscaping should be reversed.	Alot of diversity in ditches.	A person wants to see another person in the street space without making direct contact. Passive observation and participation in life is what people need.	The bicycle should be given a separate space to move, as it is a trend.

Topic		Technology and material in street planning and construction			Street features		
Inter-viewee	Background	Stormwater management	Streetlightning	Materials	Safe	Durable	Maintainable
1 M1	municipality expert	There is not enough will, knowledge, space and understanding. The entire system network needs to be rebuilt. In the case of new developments, it would be conceivable.	Dimming would be a sustainable option, but not preferred because it is expensive. Important to light the necessary places.	Local concrete, clinker, asphalt, metal elements, wooden elements are actively used. Estonia does not have the capacity to produce everything itself or the products have not been tested enough to be trusted.		Important.	
2 M2	municipality expert	Rainwater issues are being actively addressed.		Policy does not favor a more expensive solution. Local material is more expensive.			
3 M3	municipality expert	Not all projects are possible in Estonia, you have to be realistic. We must focus on reducing the area covered with hard surfaces, creating green islands.			Street space must be safe.		
4 M4	municipality expert	The street is not designed without a rainwater solution. Rainwater goes into the sewage. In the future, the rainwater will be treated to let it into the Emajõgi. In most cases it is not possible to impregnate, pipes are used. Ditches are not favored, considered dangerous.	Energy saving solutions are the trend.	Asphalt, gravel and sand is from Estonia. However, asphalt components and curbs and paving are primarily ordered from abroad.	Safe speed.		
5 ME5	municipality engineer	Everything takes up space, needs active care, the pipe is inevitable. Existing risk of the ground freezing - green systems must have a pipe.	Electrical cables could be routed underground, then there are also lower maintenance costs, better visual.		Safe movement and adequate lighting.	Thawing and freezing create holes.	There must be room for snow.

6 RE6	road engineer	The ditch is necessary if there is no water to run anywhere - it is not always functional.		The material must be suitable for the service load. Prefer paving where possible. Green paint adding to the asphalt mix helps to separate the cycle path - no road marking is required, less maintenance required. Freezing in the Estonian climate destroys pavements.		Use of time-resistant materials.	It is important to plan low-maintenance streets.
7 LA7	landscape architect	The normal water cycle depends on it, but technically rain gardens and filter systems are not easy to create in our climate - they freeze.	We don't need as much light as we do-overexposure. At night, illuminate the street over one.	Concrete and cobblestone and clinker, but it is an expensive material.		Freezing causes fragility.	There must be room for snow.
8 LA8	landscape architect	The issue is often left unimplemented because it is too local - it cannot be solved systematically through a small stretch of street. It would work in a larger area.		It is also important which construction techniques are used. There could be guidance material that shows the environmental footprint of different products. The concrete mix crumbles quickly - it makes more sense to order from the outside. In the case of curbstones use granite- more expensive, but lasts longer.	More people on the street - less danger: people's own control over the environment.	Use of durable materials.	It is important to plan low-maintenance streets.
9 LA9	landscape architect	Developers are interested in stormwater solutions that work with nature. Pipelines cannot manage rainwater, the amount of rainwater has increased. In terms of the result, the pipe and the rain garden or ditch are the same, but it should be important that this is done for the right ecological reasons.	It must not be overexposed, but it must be given to the norms, and it cannot be fully illuminated to its own approval. Energy saving solutions are the trend.	As little hard cover as possible, only where necessary.	More people on the street - less danger: people's own control over the environment.		We over-maintain the city's green spaces and incur unnecessarily more costs.

Topic		How to achieve that?				
Inter-viewee	Background	Pilot projects and tests	Rising awareness	Dividing streets and street space	Cooperation and involvement	Architectural competition
1 M1	municipality expert	Give good examples from Scandinavia, test them through pilot projects, prove the operation or non-operation of innovative systems.	Raising general awareness. Introduce new strategic thinking through the media.	Hierarchical redesign of street space is necessary.		Provides a choice of which design to work with. Different solutions for competition work. The cheapest options are no longer chosen.
2 M2	municipality expert	Small tests show that nothing happens when you change the structure of the street. Tests can also be when streets are on reconstructions and when the car traffic is restricted and diverted.		The redistribution of street space is inevitable.	It is important to involve the community in thinking.	
3 M3	municipality expert		There is no one truth, everyone has their own interests.	On the street, you have to decide who or who has the advantage. Main arteries must remain for cars.		
4 M4	municipality expert	Practice examples on site so that people can see and experience it for themselves.	Raising awareness through projects.	The street space could be divided so that the light traffic user would feel good there.	The city government decides whether or not it is necessary to involve a landscape architect.	
5 ME5	municipality engineer			Each street has its own function. Intensive traffic and light traffic do not coincide.		

6 RE6	road engineer	Bring new ideas to people through pilot projects.	The concept must be sufficiently justified to the contracting authority.	The streets must be divided into functions - main street, access street, local streets. Depending on this, the speed on the respective street can be reduced by thresholds, reversers or landscaping.	The goal of the engineer is to create a simple, reliable solution and to see that the solution works, is feasible and maintainable. Landscape architects provide rather design input.	
7 LA7	landscape architect				The collaboration between an electrical engineer and a landscape designer gives a good lighting solution. A road engineer solves the operation of a space, a landscape architect designs.	
8 LA8	landscape architect			There is a hierarchy of streets that is taken from vehicle traffic. Streets should also be divided on the importance of other aspects for example the type of streets with ecology or landscaping or the social aspect.	In order to devise strategies and systems, people need to work together and bring the topics together.	Methods could be used designing important streets.
9 LA9	landscape architect		Reaching people through information boards, seminars and the media.	The room should be able to be used in many ways - temporary events, cars, everyday events.		

Topic		Problematic themes				
Inter-viewee	Background	Ways of thinking	Lack of space	Pricing	Car preference	Regulations
1 M1	municipality expert		Routes invisible to the eye determine the distribution of street space- they are sprawling.	A cheaper solution is preferred.		Political decisions remain. No unpopular decisions are made.
2 M2	municipality expert	Current ideology and culture do not favor widespread and volatile experimentation.		A cheaper solution is preferred.	The vote of car fans is so loud.	
3 M3	municipality expert				Why do we favor car traffic, because the weather, opportunities and the comfort of people favor it.	Politicians make a choice as to which function the street should be.
4 M4	municipality expert	Ditches are dangerous.	Cities are established, there is no space over.	A cheaper solution is preferred.		
5 ME5	municipality engineer		The city gained more space (formerly Tähtvere parish), but the developments are rather modest. The narrowest and most compact streets possible are still planned.	Using cheaper options in the planning process.		
6 RE6	road engineer	The contractor's willingness to work or interest in creating something that changes the environment may be lacking - the goal is to receive money.	Utility networks place restrictions on acute projects, and their reprocessing is costly and not financially sensible.	Money influences interesting and innovative solutions. Need of convincing that investing more at first will have less cost later.	The streets are not really for parking - you should park on your lot or parking lot/house.	
7 LA7	landscape architect			Finally, the design is determined by price.	We use our comfort to drive a car. There is nothing to do that we are car-oriented.	Political decisions, what is prefered on the street.

8 LA8	landscape architect	A fast time frame requires quick design and embellishment, which must still be cheap - unprofessional activity.		Need of convincing that investing more at first will have less cost later.	The car is chosen when the movement is dangerous and uncomfortable.	Political decisions, what is prefered on the street.
9 LA9	landscape architect	Pseudo-problems of people - oaks, apple trees, ditches, etc. are not preferred because they are dangerous. People must also remain their own responsibility, not over-padding the city.			Political forces who think the car is fundamental are in the minority.	

Appendix 2. Table 2 - interviews results (Eesti keeles)

Teemad		Milline on jätkusuutlik tänavaruum?	Rohestruktuur tänavatel		Inimene ja tänavaruum	
Intervju eeritav	Taust		Rohestruktuur	Elurikkus	Inimkeskne ruum	Kergliikleja
1 M1	linnavalitsus/ ekspert	Erinevad kooslused ruumis.		Monokultuur ei ole lahendus- kooslused on. Üldsus ei soosi elurikkust.	Tänavad on eri funktsiooniga, oleneb tänavast ja vajadustest.	
2 M2	linnavalitsus/ ekspert	Inimeste eelistamine ja atribuutika roll.	Aitab kuumasaarte vastu, pakub varju. Annab emotsionaalset väärtust.		Tänavamööbel kutsub inimesi õues olema.	Eesmärk eelistada järgmises järjekorras: jalakäija, jalgratas ja siis vaatame mis autodega teeme. Liikumisviiside arendus on kõige võti.
3 M3	linnavalitsus/ ekspert	Tervislikkus- turvalisus, läbitavus ja puhkekohtade olemasolu.			Puhkekohad soosivad tervislikku eluviisi.	Teed ei ole korras ja ei soosi kergliiklejaid.
4 M4	linnavalitsus/ ekspert	Kergliiklejate hea ja läbimõeldud liikumisvõimalus.	Lillekonteinerite kasutamine tänavatel kus ruumi napib. Oluline ülekuumenemise aspektist.	Ei ole tänavate fookus, teema olulisem parkides ja rohealadel. Kraavid on ühed elurikkamad paigad.		Tähtsaim on kergliiklejate hea liikumisvõimalus.
5 ME5	linnavalitsus/ ekspert/ insener	Ei tohiks laguneda, kergesti hooldatav, ohutu.	Kui haljastusele tehakse ruumi, siis tuleb autoliiklust ümber muuta.			Intensiivne liiklus ja jalakäijad ei käi kokku.
6 RE6	teedeinsener	Ajas vastupidavad ja vähese hooldusvajadusega materjalid.				Juurdepääsutänavatel võiks kergliiklejatel olla mugav liikumine ja autodel seevastu ebamugav.

7 LA7	maastikuarhitekt	Inimkeskne, roheline, liikumist ja suhtlemist võimaldav ruum.	Ajalooline rohestruktuur määrab miljöö - kas tänavale tuleb planeerida kõrged või madalad puud. Oluline on taimede vastupidavus (pärn on populaarne). Võiks kombineerida puid, põõsaid ja rohttaimi.		Ruum, mis võimaldab inimestel kogeda ja suhelda. Inimkeskne ruum on näiteks vanalinn - autode liiklus on võimalikult ebamugav. Karloval on potentsiaal selleks muutuda.	Liikumist võimaldav. Meie kliima ei võimalda mugavat liiklemist.
8 LA8	maastikuarhitekt	Ruum, mis on kujundatud inimestele, kus eksisteerib tasakaal inimeste, haljastuse, sadevee lahenduste, autosõidu võimaluste ja sotsiaalsete võimaluste vahel.	Puud on küll olulised, aga võiks mõelda ka rohurinde peale.		Huvipunktid, poed ja vaatamisväärsused on ka majanduslikult kasulikud.	LIIKUVUSE toetamine - inimesed valiksid ratta, ühistranspordi või eelistaksid pigem jala käimist. Teekonnale peab jääma huvipunkte.
9 LA9	maastikuarhitekt	Ruum, mis pannakse paika jalakäijate ja ratturite vaatevinklist. Tänav, kus kasutatakse looduse protsesse ära.	Pigem kasutada kodumaised liike. Linnapuu peab andma varju, pakub elupaika, lõhnu, süüa loomadele. Linnas on rohkem vibratsiooni, sooja, sadet ning vähem vett - paljud taimed ei talu seda. Kui võimalik eelistada olemasolevat puud. Linnahaljastuse kontseptsioonid ja haljastuse klassifitseerimine tuleks pea peale pöörata.	Kraavid on ühed elurikkamad paigad.	Inimene tahab tänavaruumis näha teist inimest, otsest kontakti loomata. Passiivne jälgimine ja elust osa võtmine.	Jalgratas peaks saama eraldi ruumi liikumiseks, kuna on jätkuv trend.

Teemad		Tehnoloogia ja materjalide valik			Tänava omadused		
Intervjueeritav	Taust	Sademevee juhtimine	Valgustus	Materjalid	Turvaline	Vastupidav	Hooldatav
1 M1	linnavalitsus/ekspert	Tahtmist, teadmist, ruumi ja arusaamist jääb väheks. Tuleb ümber ehitada kogu süsteem võrgustik. Uusarenduste puhul oleks mõeldav.	Dimmerdamine oleks jätkusuutlik variant, aga ei eelistata, sest kallis. Ainult vajalike kohtade valgustamine.	Kasutatakse aktiivselt kohalikku betooni, klinkerit, asfalti, metallelemente, puitelemente. Eestis pole võimekust, et kõike ise toota või tooteid pole piisavalt katsetatud, et neid usaldada.		Oluline.	
2 M2	linnavalitsus/ekspert	Sademevee teemadega tegeletakse aktiivselt.		Riigipoliitika ei soosi kallimat lahendust kasutama. Kohalik materjal on kallim.			
3 M3	linnavalitsus/ekspert	Eestis pole kõik projektid võimalikud, tuleb olla realist. Tuleb orienteeruda kaetud pindade vähendamisele, rohesaarte loomisele.			Tänavaruum peab olema turvaline.		
4 M4	linnavalitsus/ekspert	Tänavat ei projekteerita sajuvee lahenduseta. Sajuvesi läheb reovette. Perspektiivis suundutakse sajuvee puhastamisele, et lasta see Emajõkke. Enamasti ei ole võimalik immutada, kasutatakse torusid. Kraave ei soosita, peetakse ohtlikuks.	Säästlikud valguslahendused on trend.	Asfalt, täitematerjal - kruus, liiv. Ent asfalti komponendid ja äärekivid ning sillutised tellitakse eelkõige välismaalt.	Ohutu kiirus.		
5 ME5	linnavalitsus/ekspert/insener	Kõik võtab ruumi, vajab aktiivset hoolt, toru on vältimatu. Meil on maapinna külmumise oht - rohe süsteemid peavad olema toruga.	Elektrikaablid saaks viia maa alla, siis on ka väiksem hoolduskulu.		Ohutu liikumine ja piisav valgustus.	Sulamine ja külmetamine tekitab auke.	Lume jaoks peab olema ruumi.

6 RE6	teedeinsener	Imbkraav on vajalik kui vett ei ole kuhugi juhtida- ei ole alati toimiv.		Materjal peab sobima kasutuskoormusega, kus võimalik eelistada sillutist. Rattateede eraldamiseks lisati asfaldisegudesse rohelist värvi- ei vaja teekattemärgistust, hooldusvajadus väiksem. Eesti kliimas külmumine lagundab katendeid.		Ajas vastupidavate materjalide kasutamine.	Oluline planeerida vähese hooldusvajadusega tänavaid.
7 LA7	maastikuarhitekt	Sellest sõltub normaalne veeringlus, aga tehniliselt vihmaaedu ja filtersüsteeme ei ole meie kliimas lihtne luua - külmuvad.	Meil pole vaja nii palju valgust kui meil seda on - ülevalgustatus. Öösel valgustada tänavat üle ühe.	Betoon ja munakivi ning klinker, aga see on kallis materjal.		Külmumine põhjustab haprust.	Lume jaoks peab olema ruumi.
8 LA8	maastikuarhitekt	Temaatika jääb sageli rakendamata, sest on liialt lokaalsed - väikese tänavajupi kaudu ei saa seda süsteemselt lahendada. Suuremal alal töötaks.		Oluline on ka, milliseid ehitustehnilisi võtteid kasutatakse. Võiks olla juhendmaterjal, mis näitab erinevate toodete keskkonnajalajälge. Betoonsegu pudeneb kiiresti- mõttekam väljast tellida. Äärekivide puhul kasutada graniiti-kallim, aga kestab ajas kauem.	Mida rohkem inimesi seda ohutum seal on - inimeste enda kontroll keskkonna üle.	Ajas püsivate materjalide kasutamine.	
9 LA9	maastikuarhitekt	Arendajad huvituvad sademevee lahendustest, mis töötaks koos loodusega. Torustikud ei suuda sadevett ära hallata, vee hulk on kasvanud. Tulemuse mõttes on toru ja imbpeenar- või kraav sama, aga tähtis peaks olema, et seda tehakse õigetel ökoloogilistel põhjustel.	Ei tohi üle valgustada, ent tuleb normidele järgi anda ja ei saa täiesti oma heaks pidamise järgi valgustada. Energiasäästvad lahendused on trend.	Võimalikult vähe kõva katet, vaid sinna kus on vajalik. Taaskasutust rohkem arendada katendite ja mööbli osas.	Mida rohkem inimesi seda ohutum seal on - inimeste enda kontroll keskkonna üle.		Hooldame liialt linna haljasalasid ja tekitame endale rohkem kulusid.

Teemad		Kuidas?				
Intervjueeritav	Taust	Pilootprojektide ja katsetuste kaudu	Teadlikkuse edendamine	Tänavaruumi jagamine	Koostöö ja kaasamine	Arhitektuurikonkurss
1 M1	linnavalitsus/ ekspert	Skandinaaviast tuua häid näiteid, katsetada neid pilootprojektide kaudu, tõestada uudsete süsteemide toimimist või mitte toimimist.	Üleüldise teadlikkuse tõstmine. Uudset strateegilist mõtlemist läbi meedia tutvustada.	Tänavaruumi hierarhiline läbi kavandamine on vajalik.		Annab valikuvõimaluse, millise disainiga edasi töötada. Erinevad lahendused võistlus tööle. Enam ei valita kõige odavamaid variante.
2 M2	linnavalitsus/ ekspert	Väikesed testid näitavad, et tänava struktuuri muutes ei juhtu midagi. Testid võivad olla ka tänava rekonstrueerimised, kui piiratakse ja suunatakse autoliiklust ümber.		Tänavaruumi ümberjagamine on vältimatu.	Tähtis on kogukonda kaasata mõttetöösse.	
3 M3	linnavalitsus/ ekspert		Ei ole ühte tõde, kõigil on oma huvid.	Tänaval tuleb otsustada kellel või millel on eelis. Põhimagistraalid peavad jääma autode jaoks.		
4 M4	linnavalitsus/ ekspert	Praktiseerida koha peal näiteid, et rahval oleks võimalik seda ise näha ja kogeda.	Kureeritud elurikkuse projekti kaudu teadlikkuse tõstmine.	Tänavaruum võiks olla jaotatud, et kergliikleja end seal hästi tunneks.	Linnavalitsus otsustab, kas on vaja maastikuarhitekti kaasata või mitte.	
5 ME5	linnavalitsus/ ekspert/ insener			Igal tänaval on oma funktsioon. Intensiivne liiklus ja kulgev kergliiklus ei käi kokku.		

6 RE6	teedeinsener	Pilootprojektide kaudu viia inimesteni uusi ideid.	Kontseptsioon tuleb tellijale piisavalt ära põhjendada.	Tänavad tuleb jaotada funktsioonide järgi- peatänav, juurdepääsu tänav, kohalikud tänavad. Sellest olenevalt saab vastaval tänaval kiirust vähendada künniste, suunamuutjate või haljastusega.	Inseneri eesmärk on luua lihtne, töökindel lahendus ning vaadata, et lahendus toimiks, oleks teostatav ja hooldatav. Maastikuarhitektid annavad pigem kujundusliku sisendi.	
7 LA7	maastikuarhitekt				Elektriinseneri ja maastikudisaineri koostöö on hea valguslahendus luua. Teedeinsener lahendab ruumi toimimise, maastikuarhitekt disainib.	
8 LA8	maastikuarhitekt			Eksisteerib tänavate hierarhia, mis on sõiduki liiklusest võetud. Peaks jagama tänavaid ka muude aspektide tähtsusest, mis tüüpi tänavatel on ökoloogia või haljastus või sotsiaalne aspekt esikohal.	Strateegiate ja süsteemide välja mõtlemiseks on vaja inimeste koostööd ja teemade koondamist.	Meetodit kasutada oluliste tänavate lahendamisel.
9 LA9	maastikuarhitekt		Infotahvlite kaudu, seminaride ja meedia kaudu inimesteni jõudmine.	Ruumi peaks saama mitmeti kasutada - autode ruum, ajutiste ürituste ruum.		

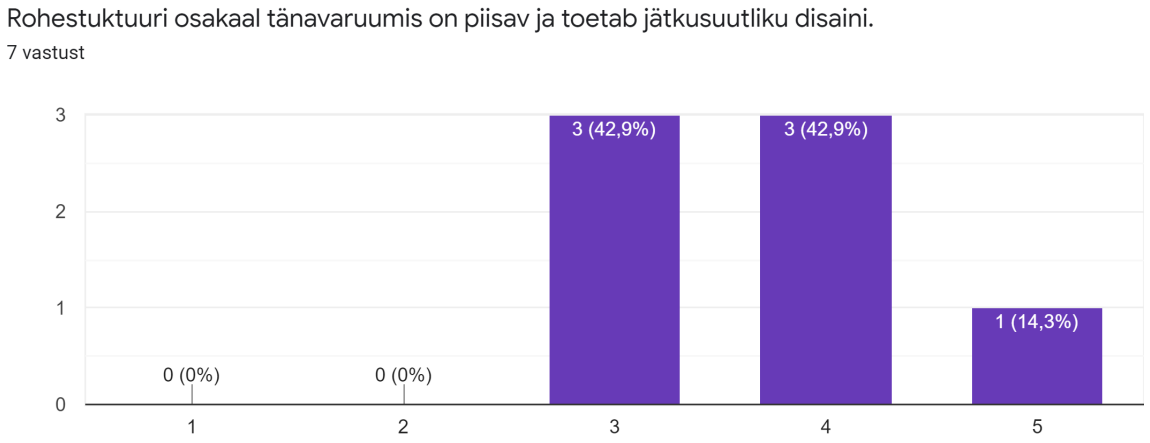
Teemad		Problemaatilised teemad				
Intervjueeritav	Taust	Mõtteviisi küsimused	Ruumipuudus	Hind	Auto	Regulatsioonid
1 M1	linnavalitsus/ ekspert		Silmale nähtamatud trassid määravad tänava- ja ruumijaotuse - laiutavad.	Eelistatakse odavamat lahendust.		Poliitilised otsused jäävad peale. Ei võeta vastu ebapopulaarseid otsuseid.
2 M2	linnavalitsus/ ekspert	Praegune ideoloogia ja kultuur ei soosi laialdasi ning lennukaid katsetusi.		Eelistatakse odavamat lahendust.	Autofännide hääl on niivõrd tugev.	
3 M3	linnavalitsus/ ekspert				Miks me soosime autoliiklust, sest ilm, võimalused ja inimeste mugavus soosib seda.	Poliitikud teevad valiku, mis funktsiooniga tänavaid soositakse.
4 M4	linnavalitsus/ ekspert	Kraavid on ohtlikud.	Linnad on väljakujunenud, ruumi üle ja saada kuskilt ei ole.	Eelistatakse odavamat lahendust.		
5 ME5	linnavalitsus/ ekspert/ insener		Linn sai ruumi juurde (end. Tähtvere vald), ent arengud on pigem tagasihoidlikud. Jätkuvalt planeeritakse võimalikult kitsaid ja kompaktseid tänavaid.	Planeerimisprotsessis odavamate võimaluste kasutamine.		
6 RE6	teedeinsener	Teostaja töötahe või huvi luua midagi keskkonda muutvat võib puududa- eesmärk raha kätte saada.	Tehnovõrgud seavad ägetatele projektidele piirangud, lisaks nende ümbertöötamine on kulukas ja ei ole pigem mõistlik rahalisest aspektist.	Raha mõjutab ägedaid otsuseid. Tuleb tellijaid veenda, et investeerides algul rohkem on hiljem vähem kulusid.	Tänavad ei ole tegelikult parkimiseks.	

7 LA7	maastikuarhitekt			Lõpuks on valikute määrajaks hind.	Kasutame oma mugavusi, et autoga sõita. Pole midagi teha, et oleme autostunud.	Poliitiline küsimus, mida tänaval eelistatakse.
8 LA8	maastikuarhitekt	Kiire ajaraam nõuab kiiresti projekteerimist ja ehitamist, mis peab veel odav tulema-ebaprofessionaalne tegevus.		Tuleb tellijaid veenda, et investeerides algul rohkem on hiljem vähem kulusid.	Auto valitakse kui liikumine on ohtlik ja ebamugav.	Poliitilised otsused.
9 LA9	maastikuarhitekt	Inimeste pseudoprobleemid-ei eelistata tammesid, õunapuid, kraave vms sest need on ohtlikud. Inimestel peab jääma ka omavastutus, mitte liialt ära polsterdama linna.			Poliitilisi jõude, kes arvavad et auto on põhiline on vähemuses.	

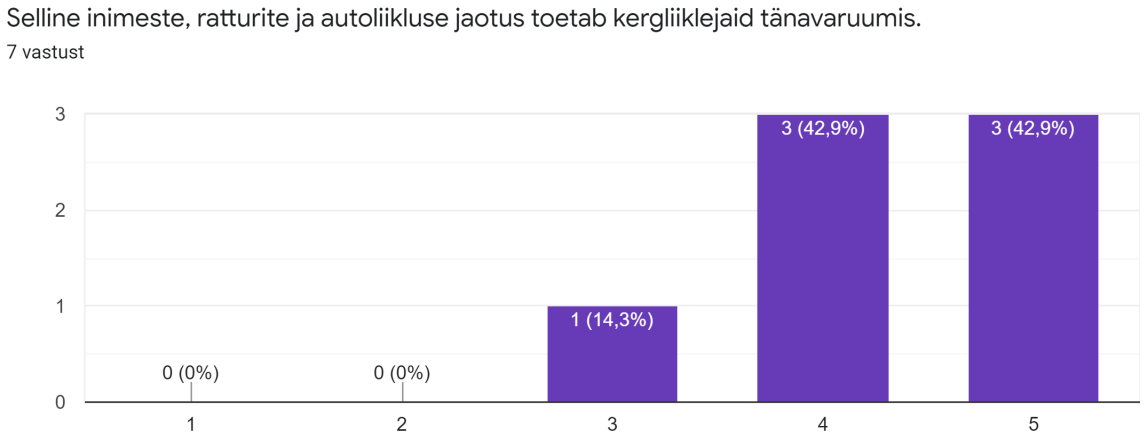
Appendix 3. Feedback data on design

Street type A

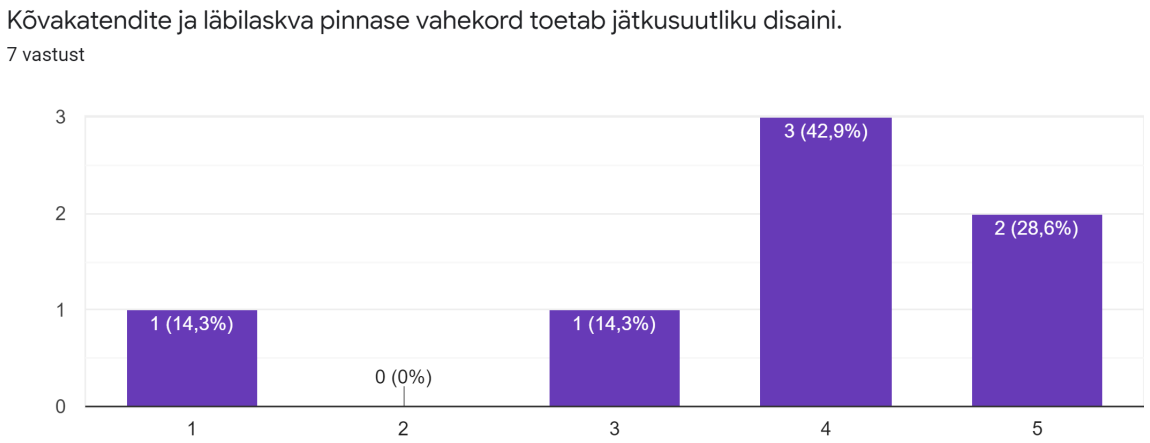
Data 1 (see figure below). Is there enough green structure planned to support sustainable design? On a scale of 1 to 5, it received an average of 3,7 points.



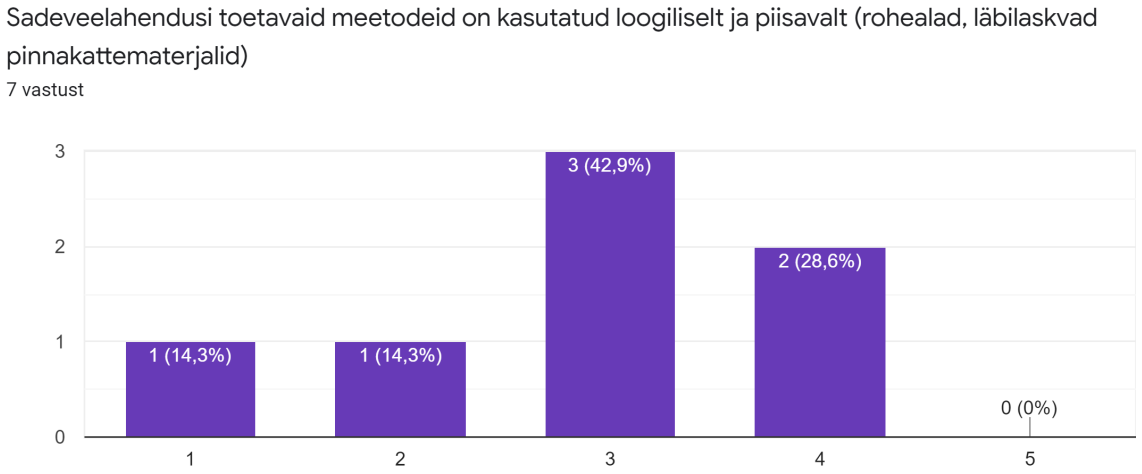
Data 2 (see figure below). Is this type of light traffic and car traffic division beneficial to light traffic on the street? On a scale of 1 to 5, it received an average of 4,3 points.



Data 3 (see figure below). Is the relationship between hard pavers and permeable pavement beneficial to sustainable design? On a scale of 1 to 5, it received an average of 3,7 points.

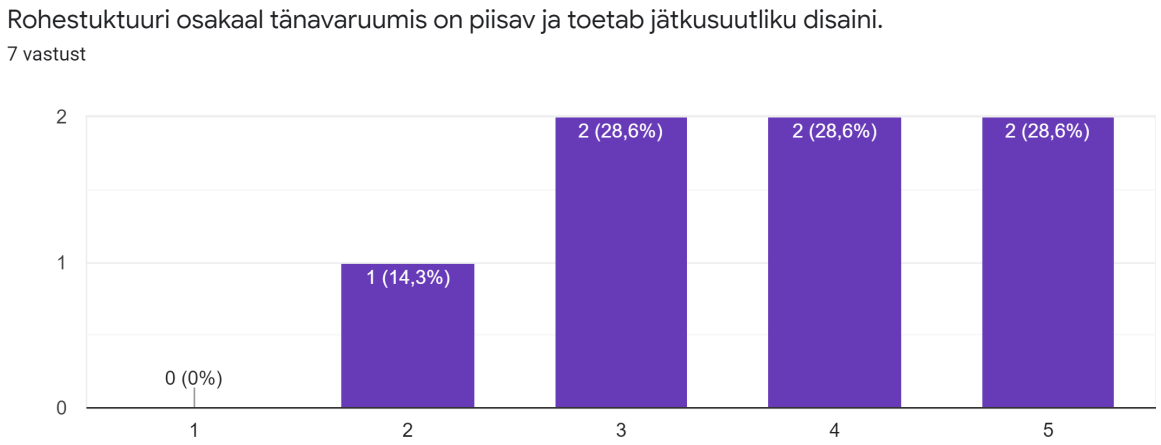


Data 4 (see figure below). Are stormwater solutions used logically and in sufficient quantities to support sustainable design? On a scale of 1 to 5, it received an average of 2,9 points.

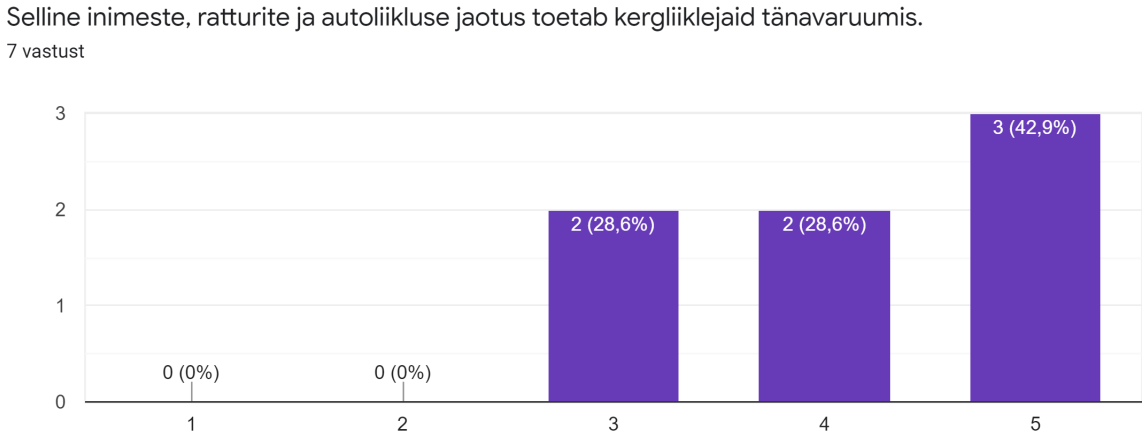


Street type B

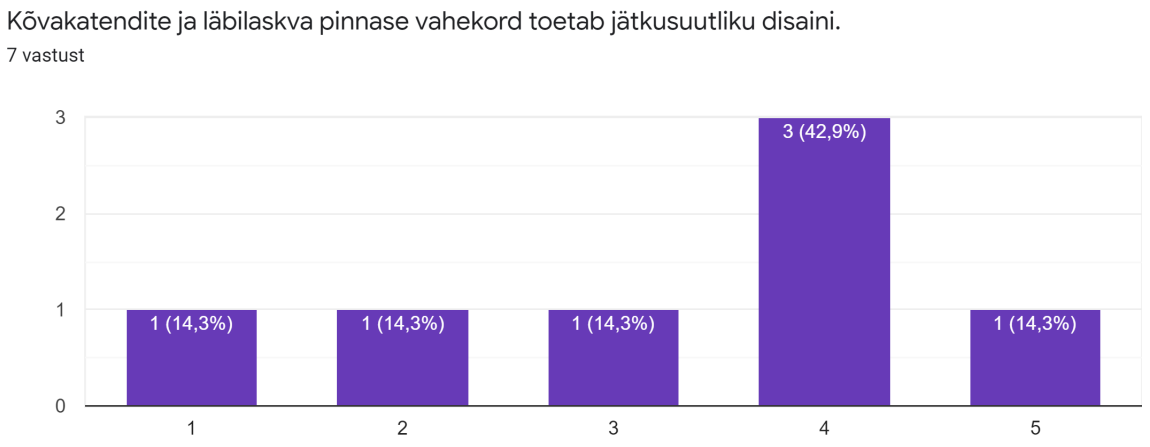
Data 5 (see figure below). Is there enough green structure planned to support sustainable design? On a scale of 1 to 5, it received an average of 4 points.



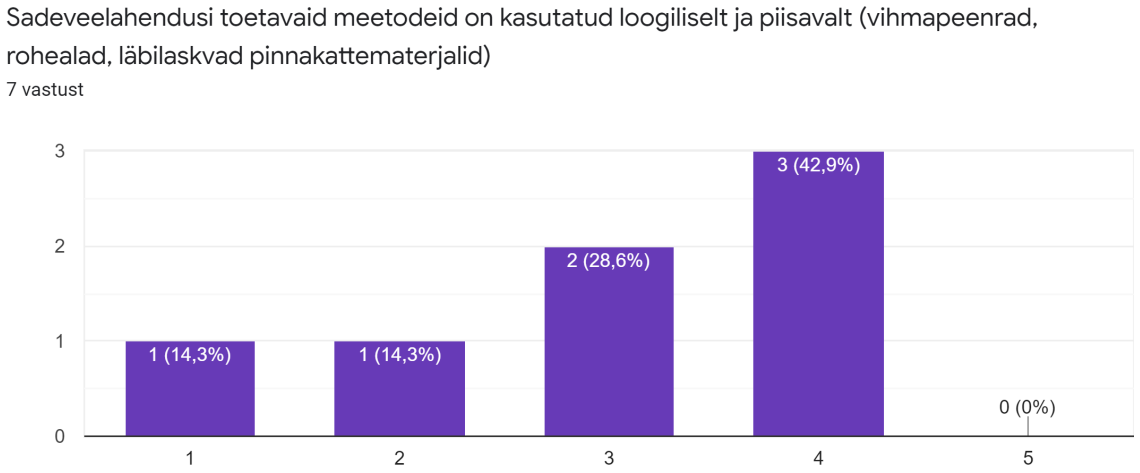
Data 6 (see figure below). Is this type of light traffic and car traffic division beneficial to light traffic on the street? On a scale of 1 to 5, it received an average of 4,1 points.



Data 7 (see figure below). Is the relationship between hard pavers and permeable pavement beneficial to sustainable design? On a scale of 1 to 5, it received an average of 3,3 points.

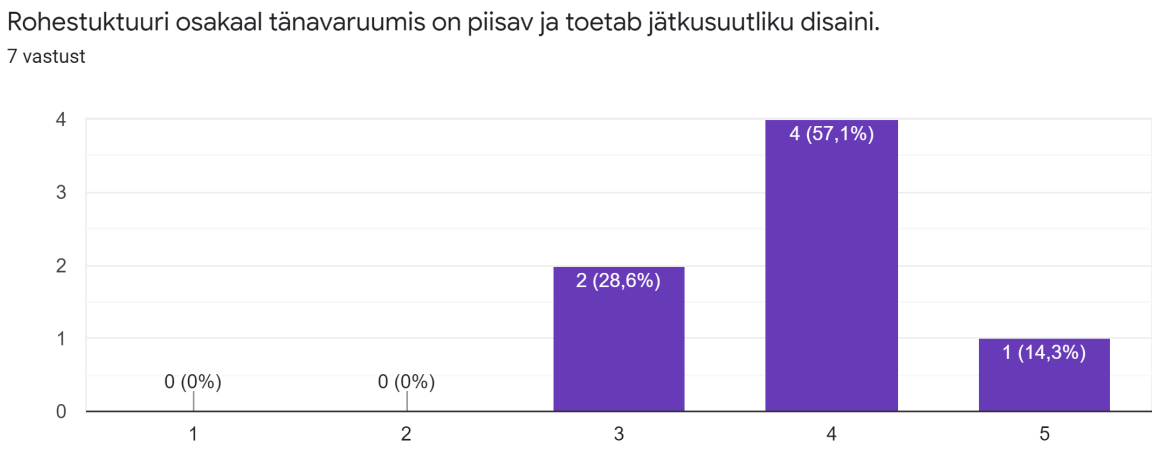


Data 8 (see figure below). Are stormwater solutions used logically and in sufficient quantities to support sustainable design? On a scale of 1 to 5, it received an average of 3 points.

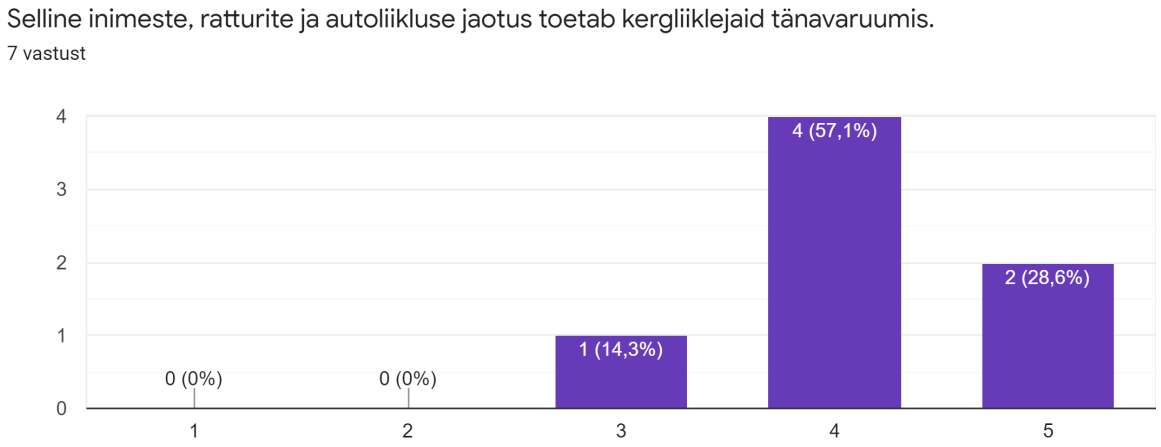


Street type C

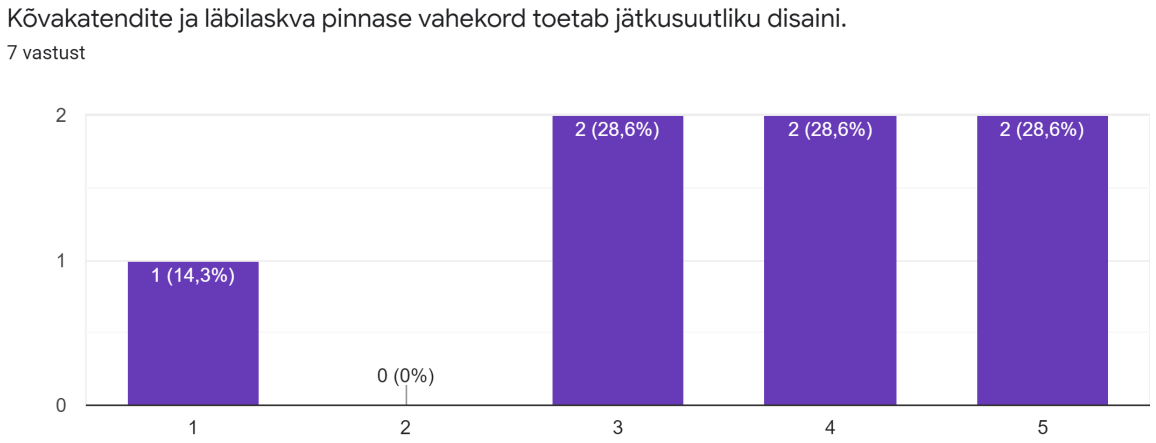
Data 9 (see figure below). Is there enough green structure planned to support sustainable design? On a scale of 1 to 5, it received an average of 3,9 points.



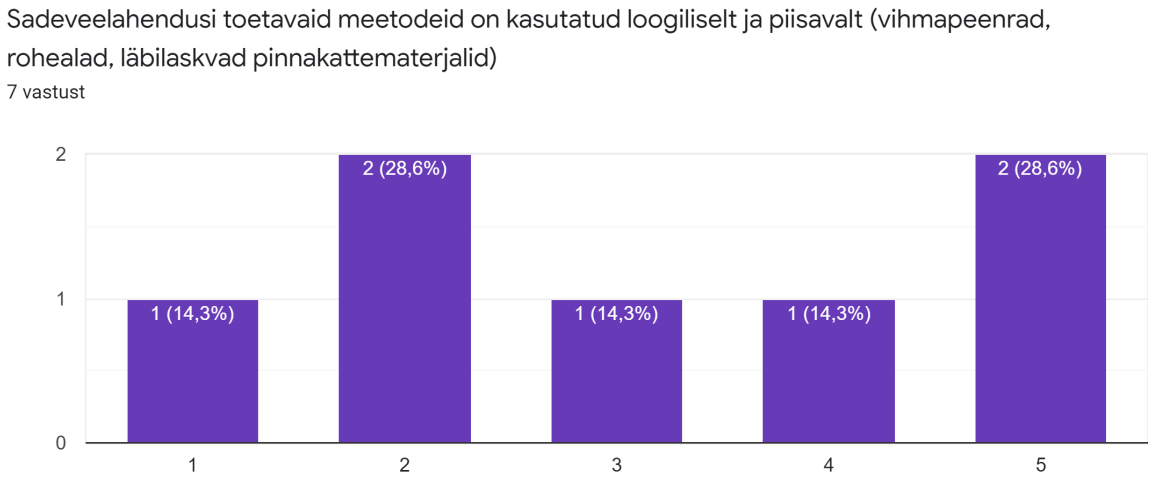
Data 10 (see figure below). Is this type of light traffic and car traffic division beneficial to light traffic on the street? On a scale of 1 to 5, it received an average of 4,1 points.



Data 11 (see figure below). Is the relationship between hard pavers and permeable pavement beneficial to sustainable design? On a scale of 1 to 5, it received an average of 3,6 points.



Data 12 (see figure below). Are stormwater solutions used logically and in sufficient quantities to support sustainable design? On a scale of 1 to 5, it received an average of 3,1 points.



Appendix 4. Lihtlitsents

Lihtlitsents lõputöö salvestamiseks ja üldsusele kättesaadavaks tegemiseks ning juhendaja kinnitus lõputöö kaitsmisele lubamise kohta

Mina, Anna Maria Järvsalu, (sünnipäev 12/veebruar/1996, 49602122717)

1. annan Eesti Maaülikoolile tasuta loa (lihtlitsentsi) enda loodud lõputöö

Sustainable street design: the case of Karlova, Tartu,

mille juhendaja on Jekaterina Balicka,

1.1. salvestamiseks säilitamise eesmärgil,

1.2. digiarhiivi DSpace lisamiseks ja

1.3. veebikeskkonnas üldsusele kättesaadavaks tegemiseks

kuni autoriõiguse kehtivuse tähtaja lõppemiseni;

2. olen teadlik, et punktis 1 nimetatud õigused jäävad alles ka autorile;
3. kinnitan, et lihtlitsentsi andmisega ei rikuta teiste isikute intellektuaalomandi ega isikuandmete kaitse seadusest tulenevaid õigusi.

Lõputöö autor allkirjastatud digitaalselt

allkiri

Tartu, 25.05.2021

Juhendaja kinnitus lõputöö kaitsmisele lubamise kohta

Luban lõputöö kaitsmisele.

Jekaterina Balicka, allkirjastatud digitaalselt 25.05.2021

(*juhendaja nimi ja allkiri*) (*kuupäev*)